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Chief of Case Administration
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Surface Transportation Board
395 E Street, SW
Washington, DC 20423

Re: Finance Docket No. 36284, Seven County Infrastructure Coalition – Rail Construction and Operation Exemption – In Utah, Carbon, Duchesne, and Uintah Counties, Utah

To the Chief:

Enclosed please find the Center for Biological Diversity et al.'s reply in opposition to Seven County Infrastructure Coalition's Motion to Reaffirm Exemption Decision in the above-caption case, filed on November 13, 2025, and our cross-move for the Surface Transportation Board to fully comply with the U.S. Court of Appeals for the District of Columbia's ruling, and to address new information that has become available since the Board completed its environmental impact statement on the Uinta Basin Railway.

We also attach 55 exhibits supporting the reply and cross-motion.

Please let me know if you have any questions.

Sincerely,

/s/ Wendy Park

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BEFORE THE
SURFACE TRANSPORTATION BOARD

Finance Docket No. 36284

SEVEN COUNTY INFRASTRUCTURE COALITION – RAIL CONSTRUCTION AND OPERATION EXEMPTION – IN UTAH, CARBON, DUCHESNE, AND UINTAH COUNTIES, UTAH

On remand from the United States Court of Appeals
for the District of Columbia Circuit

CENTER FOR BIOLOGICAL DIVERSITY ET AL.'s REPLY TO SEVEN COUNTY INFRASTRUCTURE COALITION'S MOTION TO REAFFIRM EXEMPTION DECISION AND CROSS MOTION FOR THE BOARD TO ORDER A FULL APPLICATION AND PREPARE A SUPPLEMENTAL IMPACT STATEMENT

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January 12, 2026

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BEFORE THE
SURFACE TRANSPORTATION BOARD

Finance Docket No. 36284

SEVEN COUNTY INFRASTRUCTURE COALITION – RAIL CONSTRUCTION AND OPERATION EXEMPTION – IN UTAH, CARBON, DUCHESNE, AND UINTAH COUNTIES, UTAH

CENTER FOR BIOLOGICAL DIVERSITY ET AL.'s REPLY TO SEVEN COUNTY INFRASTRUCTURE COALITION'S MOTION TO REAFFIRM EXEMPTION DECISION AND CROSS MOTION FOR THE BOARD TO ORDER A FULL APPLICATION AND PREPARE A SUPPLEMENTAL IMPACT STATEMENT

The Center for Biological Diversity, Living Rivers, Sierra Club, Utah Physicians for a Healthy Environment, and WildEarth Guardians (collectively, "the Center") reply in opposition to Seven County Infrastructure Coalition's (Seven County's) Motion to Reaffirm Exemption Decision (Mtn.) filed on November 13, 2025, and cross-move for the Surface Transportation Board (Board) to fully comply with the U.S. Court of Appeals for the District of Columbia's August 23, 2023 ruling, and to address new information that has become available since the Board completed its EIS on the Uinta Basin Railway (Railway).

Seven County has moved the Board to summarily reaffirm the Board's December 15, 2021 exemption decision with little or no further analysis, in some cases explicitly asking the Board to reject the D.C. Circuit's controlling holdings. This the Board cannot do. The Board's legal errors were serious, and significant new information has come to light demonstrating that the Railway's financing is non-existent, that competition from trucks may render the Railway superfluous, and that project costs have skyrocketed. The Board should reject the Seven County's invitation to take a quick-and-dirty approach on remand. Instead, the Board should:

- deny Seven County's exemption request based on its misleading and outdated financial information, and require full-application proceedings to review financial information about the project, or, at a minimum, require Seven County to provide additional data;
- prepare a supplemental environmental impact statement pursuant to the National Environmental Policy Act (NEPA) to address: (1) the arbitrary errors and omissions in its initial review, including its failure to address the potential harm from spills, leaks, accidents, and fires along the Colorado River; (2) significant new information, including the construction and use of new oil loadouts, and new studies showing an increased risk of accidents from longer, heavier unit trains;
- prepare a new biological assessment that addresses the impact of potential oil spills into and impacting critical habitat for threatened and endangered fish in the Colorado River, and re-enter consultation with the U.S. Fish and Wildlife Service (FWS) as required by the Endangered Species Act (ESA); and
- address the Railway's compliance with the rail transportation policies (Rail Policies) pursuant to the Interstate Commerce Commission Termination Act (ICCTA), including the Board's duty to protect "public health and safety," to address "energy conservation," and to fully and accurately weigh the environmental harms against the alleged transportation benefits.

I. The Board Must Prepare a Supplemental EIS to Address Errors and Omissions in its Initial Review.

A. The D.C. Circuit's Decision that the Board's EIS Violated NEPA on Multiple Grounds Still Stands.

The Supreme Court reversed the D.C. Circuit's rulings on the Railway's failure to address the impacts from oil drilling and refining that would occur separate in time or place from the

Railway because the courts owe "substantial deference" to the Board in "where to draw the line" for indirect effects analysis and "whether to analyze environmental effects from other projects separate in time or place from the project at hand." *Seven Cnty. Infrastructure Coal. v. Eagle Cnty.,* 605 U.S. 168, 182 (2025) . But the Supreme Court nowhere addressed the Board's analysis of downline effects between Kyune, Utah—where oil trains traveling the Uinta Basin Railway would turn off onto the Union Pacific Line—and Denver, because that issue was never presented to the Court for review. Before the Supreme Court, attorneys for this Board conceded that the project's impacts from increased oil train traffic along the Colorado River were not at issue. Fed. Resp'ts' Br. in Supp. of Pet'rs at 40, 605 U.S. 168 (2025) (No. 23-975); Fed. Resp'ts' Reply Br. in Supp. of Pet'rs at 22 n.3; 605 U.S. 168;[1] *Seven Cnty. Infrastructure Coal. v. Eagle Cnty*., Oral Argument Transcript at 68-69 (U.S. Dec. 10, 2024), excerpts attached as Ex. 1.[2] The concurrence in *Seven County* concludes those claims were not before the Court. 605 U.S. at 197 (Sotomayor, J., concurrence). Far from "vindicating" the Board's entire NEPA analysis, Mtn. at 4, the majority's opinion never mentions impacts to the Colorado River, spills, or wildfires, and doesn't respond to the concurrence's characterization.

Further, the D.C. Circuit's ruling *accepted* where the Board drew the line on downline effects, finding arbitrary the substance, not the scope, of the Board's analysis. The Board's own line drawing, pursuant to its environmental regulations, led it to address impacts caused by authorizing the Railway's construction and operation, which include a doubling of rail traffic between Kyune, Utah, and Denver. Surface Transp. Bd., Final Environmental Impact Statement,

[1] Filings in the Supreme Court case are available at https://www.supremecourt.gov/search.aspx?filename=/docket/docketfiles/html/public/23-975.html.

[2] Available at https://www.supremecourt.gov/oral_arguments/argument_transcripts/2024/23-975_5h26.pdf.

Uinta Basin Railway (Aug. 2021) ("Final EIS"), Appx. T, at T-36 – T-37 (citing 49 C.F.R. § 1105.7(e)(11)(v)). The appeals court found arbitrary the Board's reasoning *within* the four corners of its downline effects analyses, including its "utterly unreasoned" rationale for minimizing the project's downline wildfire risks, flawed projections of accident risks, and ignoring water pollution risks to the Colorado River. *See Eagle Cnty. v. Surface Transp. Bd.*, 82 F.4th 1152, 1182–85 (D.C. Cir. 2023). The D.C. Circuit did not address where the Board should draw the indirect effects line. *See id*. Thus, the Supreme Court's "substantial deference" ruling neither directly addresses nor indirectly questions the D.C. Circuit's downline effects rulings.

Seven County's arguments to the contrary depend on selective quotation and an over-reading of the Supreme Court's analysis. The Supreme Court did not "reverse" the D.C. Circuit's judgment on all NEPA issues, nor did it "plainly affirm[]" the entirety of the Board's NEPA review. Mtn. at 3, 4. Seven County's contention that the Board's NEPA review "was, as the Supreme Court put it, '[a]bsolutely correct,'" is a misrepresentation. Mtn. at 2, citing *Seven Cnty.*, 605 U.S. at 191. The Supreme Court made that statement only in reference to the Board's line drawing relative to choosing to ignore the upstream impacts of induced increased oil drilling and the downstream impacts of refining. *See Seven Cnty.*, 605 U.S. at 191. Nothing else.

The Supreme Court specifically affirmed that agencies must still take a "hard look" at indirect impacts outside the project area. *Id.* at 187 ("the environmental *effects* of the project at issue may fall within NEPA even if those *effects* might extend outside the geographical territory for the project or might materialize later in time."). Seven County does not seriously dispute that downline oil train traffic is an indirect effect of the Railway or how the D.C. Circuit's holdings on downline effects run contrary to the Supreme Court's ruling. The Board should reject the Coalition's invitation to read in conclusions where none are clear.

Tellingly, Seven County fails to address this Board's regulations which *require* the agency to take a hard look at downline impacts. 49 C.F.R. § 1105.7(e)(11)(v) (requiring that the Board's EISs "[d]escribe the effects, including indirect or down-line impacts, of the new or diverted traffic over the line …."). The Supreme Court did not set aside these regulations, which still apply and bind the Board. The *Seven County* decision is not a get-out-of-jail-free card for an arbitrary analysis once the agency concludes it must address certain effects, contrary to Seven County's assertion. By arbitrarily failing to accurately describe the Railway's effects, and particularly the impacts of accidents and spills on water resources, endangered wildlife, and communities, and the potential increase in ignitions causing wildfires, the Board violated NEPA. The Board cannot ignore these factors and must address them in a supplemental EIS on remand.

B. NEPA and the Rail Transportation Policies Require the Board to Analyze Downline Effects, Including Those Caused by Increased Risk of Accidents and Fires.

The D.C. Circuit held that the Board's environmental analysis violated NEPA in at least three ways, and the Board must address each on remand. First, the appeals court held that the Board violated NEPA and the Administrative Procedure Act (APA) by relying on aggregated national accident data and ignoring and failing to respond to "specific record evidence noting that there is increased risk [of spills] from loaded, miles-long oil trains traveling through difficult mountainous terrain." *Eagle County*, 82 F.4th at 1182. Second, the D.C. Circuit found that the Final EIS failed to take a hard look at the increased risk of wildfires based on its "utterly unreasoned" assertion that "an increase in rail traffic of up to 9.5 new trains a day would not result in a significant wildfire risk because it would not be a qualitatively 'new ignition source.'" *Id*. at 1184. Third, the circuit court found that the Final EIS failed to address at all potential impacts to the Colorado River:

> there is no evidence here that the Board even considered the potential impacts on water resources downline of running up to 9.5 loaded [and unloaded] oil trains a day on the Union Pacific Line—about 50% of which abuts the Colorado River…. The Board concededly fails altogether to mention the Colorado River in the Final EIS's discussion of impacts on water resources…. This was not a "hard look" under NEPA.

Id. (citation omitted).

Seven County avers that the D.C. Circuit's decision to remand this matter to the Board without vacatur "at least implies" that the court agreed with Seven County that the Supreme Court rubber-stamped all of the Final EIS as NEPA compliant. Mtn. at 5. This is pure speculation, given that the D.C. Circuit provided no analysis with its remand decision, nor revisited or amended its original decision invalidating the substance of the Board's authorization of the Railway. What stands in black and white is the D.C. Circuit's decision on these NEPA claims, and that is what the Board must address.

Critically, the Board's duty to address these impacts in full stems not only from NEPA and the APA but from the Rail Policies. The effects of derailment, pollution from spills, and fires all overlap with, and are encompassed by, the Board's duty to ensure that transportation facilities and equipment can be operated "without detriment to the public health and safety." 49 U.S.C. § 10101(8). Accordingly, downline safety risks—which are effects of the Railway as the Final EIS assumed—fall within the agency's authority to consider in deciding whether to authorize the new line, and, must be considered in the EIS.

Seven County asks the Board to narrowly construe the Rail Policies as focused only on "safety concerns." Mtn. at 28-29. Even if the Board agrees, the narrowest definition of "safety" must still include the potential for the new rail line to cause increased accidents and oil spills, and encompasses the impacts of those spills. Derailments, and the harm that can flow from them, clearly implicate "safety." The Board's regulations underscore this conclusion, defining "safety"

impacts that must be disclosed in environmental reviews to include, inter alia, "safety practices …; contingency plans to deal with accidental spills; and the likelihood of an accidental release of hazardous materials." 49 C.F.R. § 1105.7(e)(7)(ii). The risk of oil spills meets this definition.

The Board has acknowledged the intertwining of "public health and safety" and environmental concerns, concluding that mitigation measures included in NEPA analyses to address environmental concerns were meant to address "public health and safety." *See, e.g.*, *California High-Speed Rail Authority--Construction Exemption--in Merced, Madera and Fresno Counties, Cal*., STB Docket No. FD 35724, 2013 STB LEXIS 180, at *53 (STB served June 13, 2013) ("the extensive *environmental mitigation* that will be imposed on this Project will eliminate or minimize to the extent possible potential impacts *on public health and safety*." (emphasis added)); *California High-Speed Rail Authority--Construction Exemption--in Fresno, Kings, Tulare, and Kern Counties, Cal*., STB Docket No. FD 35724, 2014 STB LEXIS 198, at *36 (STB served Aug. 11, 2014) (same).

The cases Seven County cites to allege that "public health and safety" have nothing to do with harms from spills, accidents, and fires are inapposite. Mtn. at 28-29. In *American Rocky Mountaineer*, the Board rejected "vague and speculative safety concerns that are not specific to [the rail proposal] or its proposed operations." *Am. Rocky Mountaineer, LLC – Petition for Exemption from 49 U.S.C. Subtitle IV*, STB Docket No. FD 36468, 2021 STB LEXIS 123, at *7 (STB served May 27, 2021); *see* Mtn. at 28. Here, the D.C. Circuit concluded the Board failed to address *specific* concerns directly related to the length, safety, and accident rates of trains carrying hazardous, toxic oil where they will travel along the Colorado River due to the Uinta Basin Railway. Other Board cases Seven County cited are similarly unhelpful. *Middletown & N.J. R.R., LLC – Lease & Operation Exemption – Norfolk S. Ry. Co*., STB Docket No. FD

35412, 2011 STB LEXIS 442, at *25 (STB decided Sept. 22, 2011) (dismissing "unsupported assertion" that rail operations raised safety concerns); *Ken Tenn Regional Rail Partners, Inc. – Construction & Operation Exemption – In Fulton Cnty. Ky., & Obion Cnty., Tenn.*, STB Docket No. FD 36328, 2021 STB LEXIS 169, at *10 (STB decided July 21, 2021) (concluding that an opposing party "fail[ed] to show (or even allege) that KTRRP would operate its proposed Line to the detriment of public health and safety").

Unlike the cases Seven County cites, here the Board concluded that increased oil train traffic resulting from its approval of the Uinta Basin Railway would nearly double traffic on the Union Pacific Line between Kyune and Denver, and would increase the risk of spills and accidents – in other words, that the Railway would harm "safety" and "public health" – albeit in a way that the D.C. Circuit concluded likely underestimated those risks, and failed to disclose the potential for harm to the Colorado River and other waters. *Eagle County*, 82 F.4th at 1182-84. The Board's duty to address "public health and safety" thus makes it *substantively* imperative that it take a hard look at, and understand, the derailment risks, and not just wave them away as Seven County asks the Board to do.[3]

In sum, the Board's duty to "operate transportation facilities and equipment without detriment to the public health and safety" reinforces the requirement that the Board address in a

[3] Seven County's argument that the "public health and safety" policy can have no overlap with "environmental" concerns would read the words "public health" out of the statute, which the Board cannot do. "Public health" clearly concerns the health of the public, which can be harmed by oil spills, accidents, fires, and water pollution. The Supreme Court has long held that "[i]It is our duty to give effect, if possible, to every clause and word of a statute." *United States v. Menasche*, 348 U.S. 528, 538-539 (1955) (citation and quotations omitted); *see also Williams v. Taylor*, 529 U.S. 362, 404 (2000) (describing this rule as a "cardinal principle of statutory construction"). Courts are thus "reluctant to treat statutory terms as surplusage," as Seven County would have the Board do here. *Babbitt v. Sweet Home Chapter of Cmtys. for a Great Or.*, 515 U.S. 687, 698 (1995).

robust fashion the impacts of spills, derailments, and fires that predictably will increase due to approval of the Railway, as the D.C. Circuit directed. As addressed below, the Board cannot simply escape such review with merely "more explanation." Mtn. at 6. More analysis is required.

1. The Board must analyze downline accident risks based on relevant data.

The Board's EIS was arbitrary – and it failed in its duty to properly address "public health and safety" – because the Board analyzed the likelihood of derailment based on national data for all trains, and it assumed, without foundation, the same derailment rates should apply to the Railway's oil trains traveling through mountainous terrain. *Eagle County*, 82 F.4th at 1182. The assumption is contradicted by record evidence showing a significant increase in derailment risk from the Railway's long oil trains. *See id*. The federal Pipeline and Hazardous Materials Safety Administration (PHMSA) has determined that train cars carrying oil tend to be more susceptible to derailment, concluding that "derailments of [High-Hazard Flammable Trains] will continue to involve more cars than derailments of other types of trains." Comment of Center for Biological Diversity, EI-30487 (Feb. 12, 2021) at 16 (citing PHMSA study). The higher degree of risk is attributed to the fact that "trains are longer, heavier in total, more challenging to control, and can produce considerably higher buff and draft forces which affect train stability." *Id*. Studies published since the Final EIS was issued bolster this conclusion. *See infra* at 26-27.

The D.C. Circuit found that the Board "effectively ignored" this evidence in the Final EIS and "failed to respond to significant opposing viewpoints concerning the adequacy of its analyses," violating both NEPA and the APA. *Eagle County*, 82 F.4th at 1182 (citation omitted). *See also Transcanada Power Mktg. Ltd. v. FERC*, 811 F.3d 1, 12 (D.C. Cir. 2015) (finding it "well established" that agencies must "respond meaningfully to the arguments raised before" them) (citation & quotations omitted).

Seven County argues that the Board "need only say" that national rail accident data is best and can ignore contrary data showing an elevated accident risks from loaded oil trains because the NEPA regulation at issue has been repealed and because *Seven County* held that the Board's "expert judgment" merits deference. Mtn. at 6-7. Whatever the status of the NEPA regulations, it is arbitrary and capricious under the APA for the Board to ignore contrary evidence without any basis or analysis of the contrary data. This is not the Board exercising "expert judgment," it is abdication of that expertise. Courts "cannot defer to a void." *Or. Natural Desert Ass'n v. Bureau of Land Mgmt*., 531 F.3d 1114, 1142 (9th Cir. 2008); *Burlington Truck Lines v. United States*, 371 U.S. 156, 168 (1962) (the agency must consider "relevant factors" and articulate "any rational connection between the facts found and the choice made"). There is no basis for the Board to utilize general, national accident data for *all* trains when *specific* data concerning oil unit trains exists, and other federal agencies have utilized their expertise to rely on that specific data to address accident rates for oil unit trains. *See* U.S. Dep't of Transportation, PHMSA, Final Regulatory Impact Analysis, Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains (May 2015) at 77-78), attached as Ex. 2.[4] In any event, the PHMSA analysis is precisely the type of evidence the Board should analyze in a supplemental NEPA review, and not dismiss by merely "say[ing] so."

2. The Board must analyze the increased risk of wildfire ignitions from additional train traffic the Railway will induce.

The Board's EIS dismissed the increased risk of wildfire ignitions caused by increased train traffic downline in part because "existing rail lines are active rail lines that have been in operation for years," and so "construction and operation of the [Railway] would not introduce a new ignition source for wildfires along the downline segments." Final EIS at 3.4-43. The D.C.

[4] Available at https://www.regulations.gov/document/PHMSA-2012-0082-3442.

Circuit found this analysis "utterly unreasoned" and that it violated NEPA's hard look mandate. *Eagle County*, 82 F.4th at 1183-84.

Seven County alleges that the Board's error here is "just poor phrasing," and that the Board can simply dismiss any fire risk as "minuscule" without further analysis. Mtn. at 8. In doing so, Seven County misses the cascade of errors the D.C. Circuit identified: the Board's complete dismissal of impacts from the significant increase in train traffic downline to Denver; the Board's reliance on fire data from existing traffic, when the Railway will cause a significant increase in traffic; and the Board's underestimate of the accident rate for large oil trains, addressed *supra*, given that accidents are a likely source of ignitions. The Board must take a hard look at the evidence, and cannot simply wave away the impacts as "minuscule" without any support for that conclusion. This is particularly so given the D.C. Circuit's finding that "there is a substantial probability that th[e] significant increase in rail traffic [downline caused by the Railway], will increase the risk of train derailments, oil spills, [and] wildfires." *Eagle County*, 82 F.4th at 1171 (citation & quotations omitted). Supplemental NEPA review is required.

3. The Board must take a hard look at the risks to downline water resources.

The Board's EIS "fail[ed] altogether" to address an issue of profound importance to the people, communities, and wildlife in Colorado, and one inextricably tied to the Board's duty to address "public health and safety:" the potential for oil spills impacting the Colorado River, along which thousands of loaded oil trains will travel each year for decades due to the Board's approval of the Railway. *Id.* at 1184. The Final EIS "omitted downline effects of projected increases in spills and accidents from additional oil trains traveling the existing Union Pacific rail line alongside the Colorado River—including effects on water, special status species or habitats, and recreation and land use." *Id.* at 1168. The D.C. Circuit held that "the Board offers no

citations that explicitly reference possible impacts" to the Colorado River, "[n]or explains why, as it says, 'the impacts are the same [as impacts along the 88-mile Railway line] and apply to both.'" *Id.* at 1184 (citation omitted); *see also supra* at 5-6.

Seven County argues that "it would not be hard" for the Board to correct these errors, pointing to the Board's analysis of accident rates downline and its allegation that Uinta Basin waxy crude oil would not disperse to water and would be easily cleaned up, and so "the Board could readily find that the new rail line presents minimal risk to downline water resources." Mtn. at 8, 9. Here, Seven County gets ahead of itself. The Board's serious errors in ignoring impacts to downline water resources cannot be explained away based on Seven County's empty assurances offered in its Motion; they require supplemental analysis and an opportunity for public review. The Board may reach any number of conclusions once it takes a "hard look" at the evidence; but it must take that hard look first. And when the Board does so, it will find the evidence currently in the record cannot simply be explained away as Seven County suggests.

The Board cannot comply with NEPA by merely providing additional explanation concerning what is in the record because the record does *not* address the potential for unique impacts to the Colorado River and communities there. The Final EIS's "surface water study area" explicitly excludes downline areas, Final EIS at 3.3-2, as did Seven County's "field survey data" that the Final EIS reviewed. *Id*. at 3.3-5 – 3.3-7. The Final EIS section analyzing "Accidents and Spills of Hazardous Materials," *id*. at 3.3-29 – 3.3-30, contains no site-specific information; it merely addresses general spill impacts. The Final EIS contains no information about the response capabilities of communities along the Union Pacific Line in Colorado, and there is no evidence that Seven County's "voluntary mitigation measures to minimize potential impacts related to spills of crude oil" that the Board relies on apply downline. Final EIS at 3.3-33.

What evidence is before the Board affirms that accidents will occur and spills will foul lands and waters downline in Colorado. The Final EIS projected that downline accident risks would more than double to three accidents annually, with an accident involving a loaded oil train occurring nearly once per year, Final EIS at 3.2-6 – 3.2-7; acknowledged that the consequences of train accidents include explosions, fires, and oil spills, *id*., Appx. E at E-1 – E-5; and projected an accidental release would occur roughly once every four years, with nearly three-quarters of those spills likely to release 30,000 gallons or more of crude oil, *see id*. at E-5. Seven County also again ignores that significant record evidence shows that the Final EIS's derailment risks estimates are likely low, given that increased risk of derailment in mountainous terrain, *see Eagle County*, 82 F.4th at 1182, and with longer, heavier, stiffer, and more challenging to control oil-laden tankers. *See supra* at 9.

Second, Seven County's contention that "the candle-like waxy crude from the Uinta Basin is so easy to clean up, it poses no threat" is contradicted by evidence before the Board and publicly available. Mtn. at 1. The facts – which the Board must evaluate in a supplemental EIS – tell a different story.

The Board acknowledges that the only foreseeable cargo that Railway will carry downline from Kyune, UT to Denver, CO, namely "Uinta Basin crude oil[,] is toxic, and an accidental release would have negative effects on the environment." Final EIS at 3-3.30. Uinta Basin crude is a "hazardous" and flammable material. Uinta crude is flammable, may cause genetic defects, may cause cancer, and may cause damage to organs through prolonged or

repeated exposure. *See* Ovintiv Safety Data Sheet, Black Wax Crude Oil, attached as Ex. 3; [5] Ovintiv Safety Data Sheet, Yellow Wax Crude Oil, attached as Ex. 4.[6]

Studies cited in the Final EIS demonstrate that oil may be difficult to remove from water and can harm wildlife. The Final EIS acknowledges that "waxy crude oil may persist in the environment for a longer time relative to other non-waxy crude oil." Final EIS at 3.3-30. For that conclusion, the Final EIS relies on a report that briefly describes a 1,000-barrel spill of waxy crude from an offshore rig near Newfoundland in 2004 that killed 10,000-16,000 birds. M. Boufadel *et al*., The Royal Society of Canada Expert Panel: The Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments (2015) at 262, excerpts attached as Ex. 5.[7]

EPA and State of Utah documentation concerning four Utah spills of waxy crude oil from trucks since 2010, two of which the Board has not previously addressed, show that relatively small spills are not easy to clean up. Instead, addressing Uinta Basin crude spills can be time-consuming and costly; can require diverting or reducing streamflows, forcing downstream users to limit their uses or seek alternate water sources; and can be complicated by weather events, including flash floods and freezing temperatures. These four spills include: a 2025 spill in a tributary of the Price River; a 2018 spill in the Price River, a 2015 spill in the Provo River, and a 2010 illegal dumping incident into the Strawberry River.

The 2025 Helper Jade Energy oil spill involved two trucks colliding and spilling "[a]n estimated 10-25 barrels … into Consumers Wash, leading to the Price River." EPA, Helper Jade

[5]Available at https://www.ovintiv.com/wp-content/uploads/2019/10/black-wax-crude.pdf.
[6]Available at https://www.ovintiv.com/wp-content/uploads/2019/10/yellow-wax-crude.pdf.
[7] Available at https://rsc-src.ca/en/behaviour-and-environmental-impacts-crude-oil-released-into-aqueous-environments.

Energy Oil Spill (Sep. 2025), attached as Ex. 6. The spill resulted in crude oil "impact[ing]" two agricultural diversion canals. *Id*. An upstream dam was asked to reduce the river flow "to allow for crude oil recovery and prevent further migration." *Id*. A lawsuit alleges that cleanup costs for the spill "may exceed $4 million." Complaint, *General Star Indemnity Co. v. Jade Energy*, LLC, 2:25-cv-01022 (D. Utah Nov. 7, 2025), attached as Ex. 7. Photos show that while some oil solidified, oil also became a sheen and small globules on the surface.



A photo from EPA's report on the 2025 Helper Jade Oil Spill, captioned "Oil floating on surface of water." *See* EPA, Helper Jade Energy Oil Spill (Sep. 2025), attached as Ex. 6.

The 2018 Price River spill involved roughly 4,000 gallons, and caused crude oil to "form quarter-size to fist-sized waxy globules scattered along (a) three-mile stretch of river from the crash site." C. Woodruff, "The Canyons: Oil and water could mix in Colorado River country

known for its beauty, fragility," Colorado Newsline (June 28, 2023) attached as Ex. 8. A series of flash floods after the spill knocked out containment booms and sent the oil farther downstream, with "'significant contamination' ending five miles from the crash." *Id*.; *see also* Utah Dep't of Environmental Quality, Price River Oil Spill (July 2018) attached as Ex. 9. Extreme measures were required to limit harm to the River: "Approximately 98% of the water above the spill location [was] routed around the spill and returned to the river below a second set of booms." EPA, Site Profile - Price River Oil Spill - EPA OSC Response (2018), attached as Ex. 10.



2018 Price River Spill. Utah Dep't of Environmental Quality captions: (L) "Oil globules form on rocks;" (R) "Emergency crews set up absorbent booms to trap oil before it heads downstream." *See* Utah Dep't of Environmental Quality, Price River Oil Spill (July 2018) attached as Ex. 9,

The 2015 Provo River spill resulted in about 1,000-1,500 gallons of oil (35 barrels) entering water following a truck crash. EPA, Site Profile - Provo Canyon Crude Oil Spill - EPA OSC Response (2015), attached as Ex. 11. EPA indicates that cold weather and "quick thinking" probably prevented the oil from entering an intake for the drinking water supply for Orem,

Provo, and Salt Lake City. A boom "appears to have successfully captured *much* of the oil." *Id*. (emphasis added). EPA reported that the water intake was closed for six days, and that it was almost two weeks later, "[d]uring a brief warming period," that "crews were able to collect oil that had been stranded in ice." EPA, Final Removal PolRep, Provo Canyon Crude Oil Spill (2015), attached as Ex. 12. EPA reported that "[t]he boom will remain in place through Spring 2016 to collect any oil that might have been stuck in the ice or vegetation," indicating the months-long nature of the response. *Id*.

The 2010 Strawberry River spill involved an "unknown party discharg[ing] up to 40 barrels [1,700 gallons] of [waxy] crude oil from a truck, likely with some amount of produced water" into the Strawberry River just upstream of its confluence with the Duchesne River. EPA, Site Profile - Duchesne Oilfield Dumping Incident (2010), attached as Ex. 13. A local irrigation district reduced the River's flow by nearly 90%, down to 15 CFS, to facilitate the cleanup. *Id*. The contamination "left oily residues along the riverbank," requiring clean up of "oiled vegetation and globules of crude," *id*., over a 10-day period and costing "almost $500k," EPA, Duchesne Oilfield Dumping Incident, NRC Report 955263 (Sep. 24-Oct. 6, 2010), Slide 10, attached as Ex. 14. EPA's decision to reduce flows in the river led the Utah State Engineer's office to complain that the action could constitute a "taking" of downstream water rights. Letter of K. Jones, Utah State Engineer (Sep. 29, 2010), attached as Ex. 15.



2010 Strawberry River spill. EPA captioned both photos: "Oiled vegetation in the Strawberry River." EPA, Duchesne Oilfield Dumping Incident, thumbnails (2010), available at https://response.epa.gov/site/image_list.aspx?site_id=6383.

These four incidents paint a different picture than the rosy one Seven County provides. They involve relatively small incidents (less than 40 barrels of oil in each, compared to the 714 barrels contained in a standard oil tank car) causing spills into relatively small water bodies, where booms could be easily placed across a narrow river or stream. Even so, the costs were significant (an estimated $4 million for the most recent spill); cleanup and monitoring required days of work, and months in at least one case; oil formed in some cases into small globules that appeared difficult to remove, soiled vegetation, and/or adhered to rocks; and little data was collected on long-term impacts to water quality or aquatic life. Containing spills also repeatedly involved drastic reductions or diversions of stream flows; cutting flows in the high-volume Colorado River to low enough levels to allow for oil to be cleaned up could be challenging and could have devastating impacts to the agricultural and recreational (rafting, boating, fishing) economies of local communities. This is the type of data and analysis the Board must address in a supplemental EIS, and apply in an analysis of oil train impacts on the Colorado River, a water source significantly different in size, flow, and other features.

Seven County further argues that the Board should ignore the D.C. Circuit's downline effects holding because it "depends on the assumption that up to 9.5 loaded *oil trains* a day will travel on the existing Union Pacific line," when under the "common carrier" obligation, trains exiting the Uinta Basin could carry anything. Mtn. at 10 (citation & quotations omitted). This is disingenuous. It is the *Board's* conclusion in the Final EIS, based on the *Railway's earlier representations*, that crude oil is the only foreseeable cargo that will leave the Basin. "The Coalition anticipates rail traffic on the proposed rail line would primarily consist of trains transporting crude oil…. The Coalition has also indicated that the other products could move on the rail line, though the volume of these products *would be very low*." Final EIS at 3.3-29 (emphasis added). *See also id*. at 3.13-13 ("OEA [the Board's Office of Environmental Analysis] did not assess the environmental impacts associated with the transportation of commodities other than crude oil and frac sand because the volumes of those other commodities would be low and because *there are currently no reasonably foreseeable plans for transporting those commodities*") (emphasis added). Nothing in the *Seven County* decision, or in the common carrier obligation, allows the Board to close its eyes to the best available data, which is that the Uinta Basin Railway is an oil train project.

Finally, the Board should robustly address issues concerning spills downline from the Utah border to Denver in a supplemental EIS because this issue is one of tremendous concern to the people of Colorado and their elected officials, many of whom have raised concerns about the project's impacts to their waters, their communities, and their economies.[8] The Railway may

[8] *See* Boulder County Commission (Aug. 11, 2022), FD 36284 Filing 305130; Gilpin County Commission (July 19, 2022), FD 36284 Filing 305129; U.S. Sen. Michael Bennet and Rep. Joe Neguse (July 13,2022), FD 36284 Filing 304990. *See also* Collected letters of Colorado elected officials concerning the Uinta Basin Railway (2022-2023), attached as Ex. 16.

benefit oil drillers in the Uinta Basin and the small population there, but it places only costs and provides no benefits to those living downline. The law requires a hard look and requires the Board to address "public health and safety" regardless of the common carrier obligation. Giving short shrift to downline impacts as Seven Couty suggests will not only violate the law, it will undermine the perceived legitimacy of the Board's decision.

C. New Information Since Publication of the EIS Requires Preparation of a Supplemental EIS.

The Board must prepare a supplemental EIS not only to correct the deficiencies the D.C. Circuit identified but also to address significant new information about the project's purpose and need and its potential impacts that has emerged since the Board authorized the Railway in 2021. A supplemental EIS is required "where necessary and appropriate to address substantial changes in the proposed action or significant new and relevant circumstances or information." 49 C.F.R. § 1105.10(a)(5). The Board must provide notice and comment on a supplemental EIS "to the extent practical." *Id*. Significant new circumstances and information bearing on the need for the Railway and its transportation merits, and on the Railway's safety risks, compel the Board to prepare a supplemental EIS. These are not mere "flyspecks" that the Board can ignore, because they demonstrate that the environmental and economic baseline conditions in the Basin and impacting oil shipment have shifted dramatically in the last four years.

1. New information about new and existing truck-to-rail loadouts constitutes significant new information about the economic and environmental baseline.

The construction of new oil transloading facilities and expansion of existing loadouts represent significant new circumstances or information related to both the Railway's impacts, and its potential purpose and need. These facilities allow significant quantities of oil to be trucked from the Basin to be transloaded onto rail cars near Price and Helper, Utah, where they

connect to the Union Pacific Line between Utah and Denver for transport to refineries in the Gulf Coast. Since the Board issued its Final EIS in 2021, the entire regional trucking system has expanded dramatically with major transportation companies pursuing rail loading capacity that now exceeds the Railway's projected 350,000 barrels per day (bpd) capacity. This significant increase in trucking will mean more oil moving, more trucks moving, more potential for accidents, and more air impacts, significantly changing the baseline conditions under which the Railway would operate. These impacts could potentially add to impacts generated by the Railway, increasing the overall cumulative potential for trucking accidents, ozone violations, and disruption from traffic delays and noise. They could also undercut the financing and purpose and need for the Railway. These major developments present a seriously different picture of the economic and environmental baseline, and thus require the Board to analyze them in a supplemental EIS.

Although the Final EIS assumed that the Railway may divert a small volume of truck traffic going to and from the Price River Terminal, Final EIS at 3.1-8, in the years since the Final EIS was published, millions of dollars in investments have been plowed into expanding existing truck-to-rail loadouts and developing new ones. One of the Basin's largest oil producers, Finley Resources, has a "majority" ownership in Wildcat Midstream, the owner/operator of the existing Wildcat Loadout, and thus a direct stake in its continuing operations. D. Boyd, *Operators, Midstream Players Pursuing Upside Opportunities In Uinta, Denver-Julesburg Basins*, American Oil and Gas Reporter (Sep. 2025), attached as Ex. 17.[9] Wildcat Midstream plans a 422-acre

[9] Available at https://www.aogr.com/magazine/editors-choice/operators-midstream-players-pursuing-upside-opportunities-in-uinta-denver-julesburg-basins; *see also* C. D'Angelo *Meet The Secretive 'Mastermind' Behind Utah's Oil Boom,* Huffington Post (Jan. 31, 2024),

expansion of the loadout, for which it has secured all "[d]esign, engineering, permitting and materials." Wildcat Midstream, Terminal Expansion Phase 1 Begins (Mar. 5, 2025), attached as Ex. 19.[10] Wildcat Midstream has touted that it has "long-term agreements" with an "offloading terminal in Louisiana," "supported by partnerships with key upstream producers in the Basin." *Id*. Last month, the Utah Division of Air Quality (UDAQ) approved Wildcat's plan to increase its maximum oil throughput to 74 million barrels per year (200,000 bpd). UDAQ, Approval Order: DAQE-AN150710006-25 Modification to Approval Order DAQE-AN150710005-24 to Expand Transloading Operations (Dec. 4, 2025) at 7, attached as Ex. 20.[11]

It is hardly likely that Finley—as the loadout's owner and user—would abandon this major investment and switch to rail shipping, absent significant cost savings from a switchover. Moreover, according to Jim Finley, Finley's CEO and partner in Wildcat Midstream, Finley has been providing the loadout to other Basin producers "at cost," foregoing any profits on shipping, to boost Basin oil production and thereby producers' bargaining power with Gulf Coast refineries. B. Larsen, *Trump administration fast-tracks oil transport expansion in eastern Utah*, Salt Lake Tribune (July 7, 2025), attached as Ex. 21.[12] Those producers are unlikely to give up their at-cost deal for pricier shipping on the Railway.

Another Uinta Basin crude oil loadout, the Price River Terminal, is backed by the largest of the transloading companies (Energy Transfer), and producer FourPoints LLC. J. Stagl, *Dual Class I-served oil terminal to double capacity by late 2026*, Progressive Railroading (Dec. 10,

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https://www.huffpost.com/entry/texas-oilman-jim-finley-utah-oil-boom_n_65aaa010e4b041f1ce65d0a1, attached as Ex. 18.

[10] https://wildcatmidstream.com/blog-post-title/.

[11] Available at https://daqpermitting.utah.gov/DocViewer?IntDocID=159810&contentType=application/pdf.

[12] Available at https://www.sltrib.com/news/environment/2025/07/07/trump-admin-expedites-approval/.

2025), attached as Ex. 22.[13] FourPoint and Energy Transfer's owner and operator have "forged an agreement … to double the facility's daily export capacity to 140,000 barrels" by the end of 2026. *Id*. In March 2025, the Price River Terminal won approval from UDAQ to transload up to 43,800,000 barrels per year (120,000 bpd) through storage tanks, and another 3.65 million barrels per year (10,0000 bpd) through mobile operations. UDAQ, Price River Terminal, Approval Order: Modification to Approval Order DAQE-AN148620003-20 to Increase Transloading Limits and Add a Storage Tank, Project Number: N148620004 (Mar. 27, 2025), attached as Ex. 23.[14]

A third facility, the Savage Wellington Transload Terminal, is also moving forward. *See* Savage, Savage Wellington Transload Terminal to Provide Utah Crude-by-Rail Connection, Unlock Economic Growth Opportunities for Producers and Refiners (Jan. 8, 2025), attached as Ex. 24.[15] Savage has acquired 277 acres of land and state subsidies; permitting, engineering, and design are complete. *Id*. In October 2025, UDAQ approved the terminal for a maximum throughput of 29.2 million barrels of oil per year (80,000 bpd). UDAQ, Savage Infrastructure LLC - Wellington Crude Transloading Facility, Approval Order: Modification to Approval Order DAQE-AN161780001-24 to Increase Crude Oil Transloading Limits and Add Equipment, Project Number: N161780002 (Oct. 2, 2025) at 6, attached as Ex. 25.[16]

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[13] Available at https://www.progressiverailroading.com/RailPrime/details/Dual-Class-I-served-oil-terminal-to-double-capacity-by-late-2026--75939?utm_source=prwebsiteorganic&utm_medium=prwebsite&utm_campaign=sitenav.

[14] Available at https://lf-public.deq.utah.gov/WebLink/DocView.aspx?id=555561&dbid=0&repo=Public/.

[15] Available at https://www.globenewswire.com/news-release/2025/01/08/3006417/0/en/Savage-Wellington-Transload-Terminal-to-Provide-Utah-Crude-by-Rail-Connection-Unlock-Economic-Growth-Opportunities-for-Producers-and-Refiners.html.

[16] Available at https://lf-public.deq.utah.gov/WebLink/DocView.aspx?id=611951&dbid=0&repo=Public&cr=1.

UDAQ's air quality permits show these three terminals in Carbon County have a total approved oil throughput capacity of 410,000 bpd, 117% of the high-end estimate of the 350,0000 bpd that the Board predicted the Railway will carry. Final EIS at 2-35.

This new information is significant in at least three ways. First, the construction of these loadouts begs the question of whether the Railway remains financially viable given competition with the truck-to-loadout alternatives, which goes to the purpose and need for the project. These loadouts will potentially directly compete with each other, begging the question of how the Railway will fit in. J. Renton, ET, FourPoint to expand Uinta Crude Terminal, Crude Oil Edge (Oct. 29, 2025), attached as Ex. 26 ("The Price River project will compete directly with Wildcat Midstream's expansion of the Wildcat Terminal near Helper, UT.").[17] Notably, unlike Seven County and the Uinta Basin Railway, transloading operators in the Basin have identified long-term customers for their expansions and are not primarily relying on public funds for their projects. This raises questions as to whether the Railway can attract shippers at the price required to maintain operations long-term and while competing with the loadouts. Indeed, with several alternatives that producers now have to move oil out of the Basin, Utah Petroleum Association's and producers' support for the Railway is now in question, and is contingent on whether rail is cost-competitive compared to the loadouts. *See infra* at 50-51.

Second, this new information calls into question the Final EIS's assumption that the Railway will displace some (or any) truck traffic moving out of the Basin. The Final EIS assumes that existing truck-to-rail is primarily served by the Price River Terminal, and that the Railway will divert and reduce traffic from the loadouts to the Railway, with beneficial effects on

[17] Available at https://eastdaley.com/crude-oil-edge/et-fourpoint-to-expand-uinta-crude-terminal.

road safety, air quality, noise levels, and energy consumption.[18] But in light of significant investments that Finley and others have made to upgrade the loadouts, and the Railway's ballooning costs, the Board needs to reanalyze its assumption that the rail will divert and reduce truck traffic. A new analysis should address whether rail would be cheap enough to oust the competition (as currently assumed in the Final EIS); would be competitive enough to simply co-exist with the loadouts; or would be too costly to maintain a long-term customer base and survive the ups and downs of the oil market. Further, if the analysis shows that the Railway and the loadouts can co-exist, the analysis should address whether the Railway would lead to increased production and shipping of Uinta Basin oil.

Third, if the Railway does not displace the three loadouts, the total volume of oil transported to the UP Line from Kyune to Denver could more than double the 350,000 bpd that the Final EIS assumes. In such a scenario, the Railway's impacts when taken together with the impacts of increased shipping from the truck-to-rail loadouts in Carbon County will result in increased risk of accidents, spills, and fires downline in Colorado.

Given the significant new and relevant circumstances and information that paint a very different picture of the current market for oil transport, and the impacts that the Railway may cause, the Board must address this new information in a supplemental EIS.

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[18] Final EIS at 3.1-8 – 3.1.9 ("[O]peration of the [Railway] would reduce tanker truck mileage by approximately 2.8 million miles per year and that may lead to fewer crashes."); *id*. at 3.7-14 ("reduction in truck vehicle miles traveled would lead to reductions in the trucks' exhaust emissions" and "reduce the regional air quality impacts of the [Railway]"); *id*. at 3.6-9 ("Decreased truck traffic between oil production areas and the Price River Terminal could result in reduced noise along local roadways compared to current conditions."); *id*. at 3.8-7 ("Because this tanker truck traffic would be diverted to rail transportation if the proposed rail line were constructed, … diesel fuel consumption for truck transportation would be reduced by approximately 47,500 gallons per year.…").

2. New studies showing longer and loaded trains have higher derailment risk must be considered.

A supplemental EIS is necessary because new research contradicts the EIS's assumptions that train length and weight, and whether cars are loaded with oil, do not affect train accident rates. Just as the Board cannot ignore existing data contradicting these assumptions, *supra* at 9-10, neither can it ignore this new research. Beyond violating the APA's prohibition against arbitrary and capricious action, that blindered approach would violate the Board's substantive mandate to uphold its policy to "operate transportation facilities and equipment without detriment to the public health and safety." 49 U.S.C. § 10101(8).

One new study published in 2024 shows that longer freight trains are more likely to derail than shorter trains. P. Madsen, et al., The relationship between freight train length and the risk of derailment, Risk Analysis (2024), attached as Ex. 27.[19] Based on an analysis of freight train accident data from 2013-2022, researchers found that "running 100-car trains would lead to an 11% higher risk of derailment compared with running 50-car trains, even when accounting for the fact that only half as many 100-car trains would need to run. For 200-car trains, the risk was 24% higher than for 50-car trains." TechXplore, *Is a train's risk of derailment affected by its length?* (May 29, 2024), attached as Ex. 28.[20]

Longer trains may be at higher risk of derailment and accident severity, because they "can hamper crews' ability to operate the trains, it can take longer for brakes to stop them, and safety risks can arise when firetrucks can't get past multiple blocked rail crossings." T. Snyder, *'The longer the train, the heavier the train' — Ohio disaster calls attention to freight's growing*

[19] Available at https://www.railpassengers.org/site/assets/files/46053/risk-analysis-2024-madsen-the-relationship-between-freight-train-length-and-the-risk-of-derailment.pdf.
[20] Available at https://techxplore.com/news/2024-05-derailment-affected-length.html#google_vignette.

bulk, Politico (Feb. 16, 2023), attached as Ex. 29.[21] Longer and heavier trains also lead to increased risk of derailments, by causing increased wear and tear on tracks and equipment. *Id*.

Another 2023 study shows that "a loaded unit train is likely to derail more cars than a manifest train and an empty unit train," and that "both [manifest trains and empty unit trains] are less likely to derail than a loaded unit train." W. Li, et al., Statistical Analysis of Train Derailment Severity for Unit Trains Versus Manifest Trains, Transportation Research Record 2024, Vol. 2678(4) 30–42, attached as Ex. 31.[22]

The more cars that derail, the higher likelihood of a hazardous spill and severe impacts, such as explosions, fires, water contamination, toxic air contaminant releases, and public health impacts. These potentially significant risks make it imperative that the Board consider these new studies, and fully disclose, consider, and weigh derailment and oil spill risks and their consequences, under both NEPA and ICCTA.

D. Failure to Correct the Foregoing NEPA Deficiencies Would Infect the Board's Substantive Decision and Violate the D.C. Circuit's Mandate.

Although the *Seven County* decision upheld that the Board's decision to omit from its Final EIS an analysis of upstream drilling and downstream refining impacts, it did not explicitly disturb the D.C. Circuit's holdings that the Board violated NEPA and the APA in its analysis of accident rates, fire ignitions, and downline impacts from spills. In doing so the Board also failed to ensure compliance with the Rail Policies requiring that transportation facilities be operated "without detriment to the public health and safety." 49 U.S.C. § 10101(8). The D.C. Circuit

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[21] Available at https://www.politico.com/news/2023/02/16/ohio-derailment-train-east-palestine-00083122; *see also* United States Government Accountability Office, Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact (May 2019), https://www.gao.gov/assets/gao-19-443.pdf, attached as Ex. 30.

[22] Available at http://rail.rutgers.edu/files/li-et-al-2023-statistical-analysis-of-train-derailment-severity-for-unit-trains-versus-manifest-trains.pdf.

rightly found these flaws to be serious – to "infect [the Board's] final determination," *Eagle County*, 82 F.4th at 1194. The Board's errors involve significant issues related to the protection of drinking water supplies, imperiled fish habitat, and fires (which could threaten communities and wildlife). To redress these errors, NEPA requires the Board to prepare a supplemental EIS, which should also require the Board to reweigh the project's costs and benefits under ICCTA. Further, new information in the nearly five years since the Final EIS's publication further requires the Board to prepare a supplemental EIS.

Seven County proposes that if the Board chooses to address NEPA issues, "it should not respond to the D.C. Circuit on its own terms." Mtn. at 10. This is a remarkable suggestion. One rarely sees litigants urge an agency to effectively ignore a controlling appellate court ruling. Should the Board do so, it will be at its own peril. *Infra* at 32 (discussing law of the case). Seven County further suggests that rather than prepare a supplemental EIS, the OEA should instead "prepare an environmental memorandum explaining that, even if project opponents were right, no supplemental review is needed because the Supreme Court's rulings limit the Board's obligations on remand." Mtn. at 10. As explained above, such an approach would fail to address a controlling court order and the Rail Policies. We are also unaware of Board regulation or procedure authorizing such a "letter to the file," thus cutting out the parties and the interested public; Seven County fails to cite any such authority. The Board should reject this suggestion.

II. The Board Must Comply with the ESA by Including the Colorado River as Part of the ESA Action Area and Reinitiating Consultation with FWS.

The D.C. Circuit found that the Board (and FWS) violated the ESA in approving the Railway, a finding that the Supreme Court neither disturbed nor addressed. *Eagle County*, 82 F.4th at 1186-88. The Board must prepare a new biological assessment, and FWS a new biological opinion (BiOp) addressing the effects on listed species and their critical habitat in the

area affected by the Railway. If the Board fails to remedy these violations, then the current biological assessment and biological opinion will remain "arbitrarily narrow[,"] and "flawed[.]" *Id.* at 1188. Further, the Board's actions may result in an unauthorized "take" of endangered or threatened fish, which raises the specter of criminal sanctions pursuant to ESA Section 9. *See* 16 U.S.C. § 1540.

"The ESA requires every federal agency to 'insure that any action authorized, funded, or carried out by such agency ... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification'" of critical habitat. *Ctr. for Biological Diversity v. EPA*, 56 F.4th 55, 62, (D.C. Cir. 2022) (quoting 16 U.S.C. § 1536(a)(2)). To fulfill this duty, "action agencies," "whose planned action may have such effect," must consult with FWS pursuant to ESA Section 7, which tasks FWS with, among other things, identifying "anticipated adverse effects on species" and critical habitats. *Id*. at 62-63 (citing 16 U.S.C. § 1536(a)-(d)).

The D.C. Circuit found that the agencies' attempt to comply with the ESA's consultation obligation, and duty to insure against jeopardy and adverse modification of critical habitat, foundered on the Board's failure to properly identify the "action area" within which the agencies must address the Railway's potential effects to listed species. "Action area" is broadly defined; it includes "all areas to be affected directly *or indirectly* by the Federal action and *not merely the immediate area involved in the action*." 50 C.F.R. § 402.02 (emphasis added). Statutorily, FWS's biological opinion must "detail[] how the agency action affects the species or its critical habitat[,]" 16 U.S.C. § 1536(b)(3)(A), using "the best scientific and commercial data available," *id*. § 1536(a)(2). When the BiOp was issued, the ESA's implementing regulations defined "effects of the action" in a similarly broad manner, to include: "the consequences to listed

species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action." 50 C.F.R. § 402.02 (2021).[23]

Here, the Board drew the action area to exclude areas where effects from the Railway will occur: those downline areas where a predicted increase in train traffic will lead to more leaks, spills, and accidents fouling the Colorado River and other streams. *See Eagle County,* 82 F.4th at 1172 (finding, in the context of standing, that "there is 'substantial probability' that endangered fish in the Colorado River parallel to the downline rail line would be impacted by the Railway given the recognized risk of oil leaks and spills associated with the increased operation of trains carrying oil products."). The Board excluded the downline areas on the "unreasoned" basis that increased traffic "would not *substantially change* the severity of impacts that already exist." *Id.* at 1187 (emphasis added). The Board's erroneous exclusion of impacts meant that the agencies' ESA analysis "never considered possible risks to protected species downline," nor justified why those risks would remain unchanged. *Id.* at 1188.

To remedy these ESA violations, the Board must prepare a new biological assessment that defines the action area to include downline areas between Kyune and Denver (where, based on the "best scientific and commercial data available," oil leaks, spills, and accidents are predicted to occur), and that discloses the potential impacts to listed species of those harms. 16 U.S.C. § 1536(a)(2). This comports with the Board's commitment to the D.C. Circuit: "On remand, FWS and the Board *will address* this Court's ESA conclusions, and then the Board will assess whether the *revised* Biological Opinion has an impact on its action here." *Eagle Cnty. v.*

[23] This regulatory definition, promulgated in 2019, is the subject of ongoing litigation. *See Ctr. for Biological Diversity v. U.S. Dep't of the Interior*, 4:24-cv-4651-JST (N.D. Cal. 2024). Summary judgment briefing has concluded, oral argument was held in October, and an opinion addressing the legality of the regulatory definition of "effects of the action" is forthcoming.

Surface Transp. Bd., Response of Federal Respondents to Cross-Motions to Reaffirm Vacatur, Doc. #2129416 (D.C. Cir. Aug. 8, 2025) at 10 (emphasis added), attached as Ex. 32.

A. The Colorado River Downline Is Within the "Action Area" Because Effects from the Uinta Basin Railway Will Occur There.

The Board's failure to properly define the Railway's "action area" undermines both the Board's biological assessment and the subsequent BiOp's analysis of the Railway's effects by failing to account for its impacts on "waterways downline near the Union Pacific Line." *Eagle County*, 82 F.4th at 1187–88. These significant harms include the impacts of increased rail traffic resulting in increased water contamination and spill risks on the four Colorado River ESA-protected fish and their critical habitat from more trains traveling the Union Pacific Line along the Colorado River. *Id*.; *see also id*. at 1195 (noting Railway's projected harms include "crude oil spills in critical habitats and sensitive water resources that are home to endangered species").

Courts hold that action areas should be construed "expansive[ly]." *Defenders of Wildlife v. Babbitt*, 130 F. Supp. 2d 121, 129-130 (D.D.C. 2001). It does not matter that impacts may occur many miles away or later in time than the agency action at issue. What matters is that effects, even indirect ones, have the potential to impact listed species. For example, in *Center for Biological Diversity v. Regan*, 734 F. Supp. 3d 1 (D.D.C. 2024), the court addressed a BiOp analyzing the impacts of transferring management of the Section 404 wetlands dredge and fill permitting program from the Corps of Engineers to the State of Florida. The court ruled that it was arbitrary for the action agency to rely on a BiOp that defined the action area to avoid impacts that could occur "eventually" to listed species that used salt-water and beach habitats far downstream and far from the likely site of future dredging and filling of freshwater rivers, streams and lakes. *Id*. at 59. So too here, authorizing the Railway will have clear consequences downline in the form of leaks, spills, and accidents that are likely to foul the Colorado River. *See*

infra at 36-37. The "action area" must include downline areas even if those areas are remote from the 88-mile Railway, and impacts may occur "eventually."

The Board's "faulty reasoning" on the action area cannot be fixed by mere "explanation" on remand because the problem is with the BiOp's scope. Having "never considered possible risks to protected species," *Eagle County*, 82 F.4th at 1188, the Board lacks the information to assess those risks. Until the Board and Service expand the effects analysis as part of Section 7 consultation to include downline impacts, and conduct an effects analysis, the agencies cannot explain how the impacts from existing trains would be the same as those resulting from a significant increase in rail traffic the Railway is designed to produce. *Id.* at 1187–88.

That the Board drew its effects boundary for *NEPA* purposes to include impacts along the Union Pacific Line from Kyune to Denver, but *excluded* that same area from its ESA review further demonstrates the arbitrary nature of the Board's ESA action-area line-drawing exercise, and supports the action area encompassing the Colorado River downline. *See id*. at 1181–82; Final EIS at 3.1-12 (addressing downline impacts because the Railway will cause an increase in rail traffic and accidents there).[24]

B. Because the Railway Will Affect Protected Species and Their Critical Habitat in the Colorado River, the BiOp Must Address Those Effects.

Seven County alleges that the Board's faulty definition of the "action area" can be explained on remand not because downline areas can be excluded because there will be no effects to the Colorado River – habitat for four species of endangered fish – but because these effects are, allegedly, not "reasonably certain to occur." Mtn. at 12-13 (citing "effects" definition

[24] The Board cannot conclude that impacts downline are beyond the Board's control and so the Board can ignore them. *Defs. of Wildlife v. Babbitt*, 130 F. Supp. 2d 121, 128 (D.D.C. 2001) (rejecting an agency argument that the action area should exclude areas where the agency "has no direct authority" because "[t]hat is not the test of whether an area is part of the action area").

at 50 C.F.R. § 402.02). Specifically, they assert that market demand and independent railroad decisions may route trains elsewhere, that the risk of significant spills is not reasonably certain to occur, that waxy crude is unlikely to impact listed species, and the causal chain between the Railway and those potential effects is too attenuated. *Id*. at 17–18.

These assertions run headlong into this Board's own findings, based on the best available data, that virtually all oil train traffic leaving the Uinta Basin due to the Railway's construction will travel along the Colorado River, and that spills and accidents downline along the River are predicted. Further, FWS has concluded that oil spills can harm the four species of endangered Colorado River fish. These effects are thus "reasonably certain to occur" within the meaning of the regulatory definition, so the Board's definition of the action area should have captured them. More important, the Board (and FWS) cannot fulfill their statutory duty to "insure" against jeopardy and adverse modification of critical habitat without considering these impacts.

1. The Board reasonably projected that nearly all increased oil train traffic from the Railway would travel through Colorado along the Colorado River.

OEA concluded that nearly all of the oil train traffic leaving the Uinta Basin will travel on the Union Pacific Line from Kyune to Denver on its way to Gulf Coast refineries. Final EIS, Appx. C. The Board did so based on information from Seven County and the U.S. Energy Information Administration, among others, concerning where project proponents identified refining capacity and potential interest in Uinta Basin waxy crude. *Id*. Using this data, the Final EIS predicted that roughly 90% of all oil trains would travel toward Gulf Coast refineries, and that *all* of these trains would use the Union Pacific Line through Colorado along the Colorado River. *Id*. at C-4 – C-5. The Board relied on models showing that tracks along Colorado River are "the shortest and the 'most practical' route" toward the Gulf. Final EIS, Appx. C at C-4.

Seven County attempts to create a cloud of uncertainty around the Final EIS's projections that most oil trains will travel along the Colorado River to Denver, but its arguments are spurious. First, Seven County wrongly asserts that who operates the downline route may be relevant to where trains will travel. Mtn. at 14. Who operates the downline route has no bearing on the Board's evaluation of the shortest and most practical route (also likely to be the cheapest) between the Railway's southern terminus and the most likely refinery destinations.

Second, while Seven County does not critique the Board's model's assumptions or outputs, it nonetheless posits that the models "*may* turn out to be wrong." Mtn. at 15 (emphasis added). In making this argument, Seven County not only ignores the ESA's "best scientific and commercial data" standard but relies on no evidence at all. While Seven County states as fact that "Uinta Basin waxy crude is today being trucked to transload facilities on the Union Pacific Line, where it is at times sent through Utah, Wyoming, and Nebraska on its way to the Gulf Coast, rather than through Colorado," Mtn. at 15, the sole "evidence" it relies on is the "verified statement" of Keith Heaton. Mr. Heaton says: "*I have been told* that at least some trains travel north from the Uinta Basin through Utah, Wyoming, and Nebraska, bypassing the Colorado River corridor, on the way to refineries on the Gulf Coast," Heaton Statement at ¶14 (emphasis added). This is the very definition of rank hearsay that would be inadmissible in virtually any legal context. *See* Fed. R. Evid. 802. Mr. Heaton provides no particulars of the who, when, where, and context of his purported conversation. He provides no information concerning the volume of traffic supposedly traveling through Wyoming compared to that following the

Colorado River, or how often "at times" is. The Board cannot credit Mr. Heaton's hearsay, and thus Seven County's assertions based thereon can have no weight in the Board's analysis.[25]

Seven County further contends that the Board cannot rely on its EIS assessment of the volume and route of oil train traffic the Railway will induce because the ESA's "reasonably certain to occur" standard "sets 'a higher threshold than 'reasonably foreseeable' effects under NEPA." Mtn. at 14, citing 84 Fed. Reg. 44976, 44992 (Aug. 27, 2019). Seven County cites no supporting caselaw, and does not explain why what the Board found to be "reasonably foreseeable" is not also "reasonably certain" based on the "best scientific and commercial data available," the ESA's evidentiary standard that Seven County completely ignores.

Further, FWS has adopted subsequent regulations and in doing so walked backed the explanation Seven County relies on. *See* 89 Fed. Reg. 24268, 24269-72 (Apr. 5, 2024) (concluding that FWS must "insure" protection of listed species, and that the definition of "effects" has only been clarified, not changed, over the years). FWS further clarified that "reasonably certain" does not mean "will happen," stating that the "reasonably certain to occur requirement" "prevents the Services from engaging in speculative analyses, though *it does not require a guarantee that an effect will occur*." 89 Fed. Reg. at 29270 (emphasis added). Here, the Board's EIS did not engage in "speculative analysis" about train destinations and routes. It used tested models, information from Seven County itself, and made reasonable projections, to reach reasoned conclusions. In preparing a new biological assessment, the Board therefore must rely on this data, which constitutes the best available evidence, rather than relying on Seven County's supposition and hearsay. Simply put, it is Seven County that is urging the Board to rely on

[25] If Seven County has significant new information that the Board's model is incorrect, such data would require, and should be analyzed in, a supplemental EIS.

impermissible "speculation and surmise" rather than to apply the ESA's best available science mandate. *Bennett v. Spear*; 520 U.S. 154, 176 (1997).[26]

2. Downline accidents, spills, and leaks are reasonably certain to occur, and to affect listed species and their habitat when they do.

Seven County argues that harm to listed species in the Colorado River is not "reasonably certain" as a result of the massive increase in oil train traffic the Railway will cause because: (1) train accidents are infrequent; (2) other railroads determine where the trains will go; (3) accidents don't always involve oil releases, and many releases would be small; (4) 48% of the rail line between Kyune and Denver does not parallel the Colorado River; and (5) the nature of waxy crude oil "preclude[s] reasonably certain harm" to listed fish. Mtn. at 16-17. Again, all of these arguments are either wrong or irrelevant. Because spills, leaks, and accidents are projected to occur, likely to occur along the Colorado River, and to harm listed species, the Board's revised biological assessment must address these downline impacts.

First, accidents and chronic leaks are inevitable and reasonably certain to occur. *See supra* at 13. The Board projected that accidents are likely to occur with a specific frequency, and more likely than not will occur along the Colorado River. *Supra* at 13, 33. As noted above, the Board's Final EIS: projected that downline accident risks would more than double to three accidents annually, with an accident involving a loaded oil train occurring nearly once per year,

[26] Mr. Heaton's statement that "I have personally seen trains carrying Uinta Basin waxy crude moving north through Utah," Heaton Statement at ¶14, is also unsubstantiated. Mr. Heaton provides no basis for his observation, where or when it happened, or why he can be certain that rail cars he saw originated in the Uinta Basin, or how he could tell whether the trains were pulling empty or full tank cars. Mr. Heaton provides no evidence that he is in any way an expert on rail transport. Even if the Board should credit Mr. Heaton's unsupported observations of oil trains traveling north, such an observation does not contradict the Board's analysis, which concluded 10% of oil train traffic would travel north and west to the West Coast. Final EIS, Appx. C at C-4. And again, if the Board countenances Mr. Heaton's hearsay, this data could constitute significant new information requiring supplemental NEPA analysis.

acknowledged that the consequences of train accidents include explosions, fires, and oil spills, and projected an accidental release would occur roughly once every four years, with nearly three-quarters of those spills likely to release 30,000 gallons or more. *Supra* at 13. Per the D.C. Circuit's conclusions, these accident projections are likely underestimates in light of evidence showing that derailment risks increase in mountainous terrain, *see Eagle County*, 82 F.4th at 1182, and with longer, heavier, stiffer, and more challenging to control oil-laden tankers. *See supra* at 9. Spills downline to Denver are "effects" that the Board and FWS were required to consider, even under a "reasonable certainty" threshold.

The Final EIS also predicted that leaks from trains would occur routinely on tracks adjacent to the Colorado River. Final EIS at 3.4-47 ("Along any active rail line, including the existing UP rail line, minor leaks or drips of fuel or lubricants from locomotives, maintenance vehicles, or rail cars may occur during rail operations and, if those substances were to be deposited into waterways, impacts on aquatic organisms, including fish, would occur."). More trains, and more trains carrying oil, will cause more toxic leaks. While the Board dismissed those harms on the erroneous basis that "the proposed rail line would not introduce a new potential source of pollution along the existing UP rail line," *id*., the D.C. Circuit called this reasoning "especially flawed." *Eagle County*, 82 F.4th at 1188. Additional water contamination from leaks is reasonably certain to occur on the rail line along the Colorado River due to the Board's approval of the Railway.

Second, while other railroads may determine where oil trains will go once they leave the Railway's tracks at Kyune, the Board's experts provided a reasonable basis, relying on models, for predicting where oil trains will go – and that's along the Colorado River on the Union Pacific Line to Denver. The fact that accidents would occur when oil is carried on "other railroads," Mtn.

at 16, is irrelevant to the Board's projections, based on the best available evidence, that leaks, accidents, and spills will occur along the Colorado River due to the Board's approval of the Uinta Basin Railway.

Third, Seven County's argument that most accidents are not projected to cause spills and that many accident-caused spills in the past have been small, *id*., ignores critical data. Again, the Final EIS predicted an accidental oil release would occur roughly once every four years, with nearly three-quarters of those spills likely to release 30,000 gallons or more. *See supra* at 13. Chronic leaks are also reasonably certain to occur. As noted above, even small spills of Uinta Basin crude in the past – amounting to a fraction of 30,000 gallons – have resulted in prolonged clean-up efforts, massive stream diversions, and oiled vegetation, all of which are likely to affect listed species and their critical habitat. *Supra* at 14-18. Given that the Final EIS projected that oil train traffic induced by the Railway would double all traffic downline to Denver, and cause up to 4.8 billion gallons of oil in tank cars each year adjacent to the Colorado River and endangered species habitat there, spills will happen.

Fourth, it is uncontested that more than half of the rail line between Kyune and Denver parallels the Colorado River. *See* Mtn. at 17; Declaration of K. Clauser (Feb. 23. 2023), attached as Ex. 33. Thus, major spills are more likely than not to occur along the Colorado River, especially because the steepest, windiest, most remote sections of the downline tracks are along the River.

Fifth, despite the allegedly "candle-like" quality of waxy crude, this toxic, hazardous petroleum poses a threat to fish and their critical habitat and has not rendered "cleanup simple" in past cases, notwithstanding Seven County's glib assertion. Mtn. at 17; *see supra* at 13-14. Prior spills from trucks in Utah involving relatively small amounts of waxy crude have been

costly and time-consuming to remediate, have required diverting and reducing streamflows, and were complicated by floods and other weather conditions. *Supra* at 14-18.

Further, FWS has repeatedly concluded that toxic spills, including oil pollution, are a threat to the recovery of the listed Colorado River fish – the endangered bonytail, endangered Colorado pikeminnow, threatened humpback chub, and endangered razorback sucker – which inhabit the Colorado River and have designated critical habitat directly adjacent to the Union Pacific Line between Kyune and Denver. *See* Clauser Decl., Exh. 33, at attachment A (map).

For example, FWS found in 2019 that "[i]mminent threats of … potential spills or leaching of environmental contaminants still remain high for bonytail," and that "potential spills or leaching of environmental contaminants [among other factors] supports our previous evaluation that the bonytail remains in danger of extinction." FWS, 5-Year Review Short Form, Bonytail (June 27, 2019) at 2, 3, attached as Ex. 34. This conclusion supported an earlier status assessment that found that "[p]otential spills of petroleum products threaten wild populations of bonytail." FWS, Bonytail, (*Gila elegans*) 5-Year Review: Summary and Evaluation (July 2012) at 14, attached as Ex. 35.

FWS concluded that for the Colorado pikeminnow, "[c]ontaminants that impact water quality can reduce reproduction and survival of individuals or lead to population reductions in the case of large, toxic spills." FWS, Recovery Plan for the Colorado Pikeminnow (Sep. 2023) at 7, attached as Ex. 36.[27]

The agency has identified "species needs" for the humpback chub including "[s]uitable water quality with few contaminants and little risk of spills of petroleum products and other toxic

[27] Available at https://ecos.fws.gov/docs/recovery_plan/20230804_FinalRP_Colorado%20pikeminnow_v4_AMMsigned.pdf.

materials." FWS, Species Status Assessment for the Humpback Chub (*Gila cypha*) (Mar. 2018) at vii, attached as Ex. 37. *See also id.* at 30 (same).[28] FWS specifically identifies oil spills from trains as a threat to the chub. *Id*. at 52 (noting that rail tracks along the Colorado River "pose a risk of derailment and spills" and that "[c]atastrophic spills of hazardous materials, such as petroleum products or other chemicals are a potential threat to water quality and to Humpback Chub"). The status assessment also noted that "dead fish were observed" following oil spills on the Green and Yampa Rivers. *Id.* at 157-58.

FWS similarly found oil spills from trains on the Union Pacific Line posed a threat to the razorback sucker. *See* FWS, Species Status Assessment Report for the Razorback Sucker *Xyrauchen texanus* (Aug. 2018) at 41, attached as Ex. 38. An earlier study confirmed that "[p]otential spills of petroleum products threaten wild populations of razorback sucker." FWS, Razorback Sucker (*Xyrauchen texanus*) Recovery Goals (Aug. 2002) at 31.[29] FWS also warned that even state plans to implement quick cleanup responses to spills "may not be sufficiently rapid to minimize deleterious effects" to the razorback. *Id*. at 32.

In sum, the OEA reasonably concluded that the Uinta Basin Railway would result in a doubling of train traffic downline, that such trains would carry only oil, and predicted that leaks and spills, including spills upward of 30,000 gallons or more, would occur. The Board's failure to address local conditions and oil train accident rates means those spill predictions are underestimates. Because more than half of the downline miles of track parallel the Colorado River, and because the endangered fish that inhabit the River and their critical habitat are threatened by petroleum spills, it is reasonably certain that the Railway will affect those fish and

[28] Available at https://iris.fws.gov/APPS/ServCat/DownloadFile/196747.
[29] Available at https://ecos.fws.gov/docs/recovery_plan/RazorbackSucker_2002_Plan.pdf.

that habitat. The Board must prepare a biological assessment that addresses these facts, including designating an action area that includes the downline areas that parallel to the Colorado River.

III. Because the Uinta Basin Railway Does Not Advance the Rail Transportation Policy, the Board Should Not Authorize It.

In addressing ICCTA, "[t]he Board's fundamental task [is] to 'properly consider[] and appl[y]' the relevant Rail Policies in its determination on the Coalition's exemption petition." *Eagle County*, 82 F.4th at 1192 (quoting *Coal Exporters Ass'n of U.S., Inc. v. United States*, 745 F.2d 76, 94 n.22 (D.C. Cir. 1984)). Specifically, before the Board can grant an exemption, it must find that a full application proceeding under 49 U.S.C. § 10901 "is not necessary to carry out the transportation policy of section 10101 of this title." 49 U.S.C. § 10502. In other words, the Board must find that, "based on the record before [it]," the project "would be consistent with" one or more relevant section 10101 Rail Policies. *Cal. High-Speed Rail Auth.*, 2013 STB LEXIS 180, at *48-52. If the Board finds a proposed project is consistent with the pertinent Rail Policies and the other exemption requirements under section 10502 are met, the Board may grant an exemption if the project's transportation benefits outweigh its environmental harms. *See id*. at *63.

The D.C. Circuit firmly rejected the Board's attempted ICCTA compliance, concluding: "It is clear from the Final Exemption Order that the Board failed at every juncture." *Eagle County*, 82 F.4th at 1192. The Supreme Court did not address the D.C. Circuit's ICCTA holdings, as Seven County admits, Mtn. at 19, and so the Board is bound by, and must address, the appeals court's ruling.

The D.C. Circuit made three key findings, each of which the Board must address on remand. First, the D.C. Circuit held that: "the Board did not provide 'adequate attention' to comments questioning the financial viability of the Railway and therefore did not properly

consider the relevant economic and regulatory policies." *Eagle County*, 82 F.4th at 1192, citing *Illinois Com. Comm'n v. ICC*, 787 F.2d 616, 630 (D.C. Cir. 1986). Ignoring party comments also violated the APA. *Id*. at 1193. Second, the D.C. Circuit held that "with respect to its consideration of the environmental policies [including its duty to operate transportation facilities "without detriment to public health and safety] …. the Board did not adequately consider the incredibly significant environmental effects identified in the EIS in weighing those impacts against the uncertain transportation benefits of the Railway." *Id.* at 1194. Third, the D.C. Circuit held that "[t]he Board largely concedes in its briefing that it did not evaluate the energy conservation policy," although the Rail Policy required it to do so. *Id*.

Each of these deficiencies requires that the Board gather additional information from the Railway, and conduct additional analysis, concerning the project's financial viability, need, and its environmental impacts. Most significantly, as detailed below, substantial questions about the project need and viability cast serious doubt on the transportation merits, including the project's ability to carry out the fourth and fifth policies to "ensure the development and continuation of a sound rail transportation system" and "to foster sound economic conditions in transportation," 49 U.S.C. § 10101(4), (5). *See Eagle County*, 82 F.4th at 1192 (holding questions about the Railway's financial viability apply to these policies).

Because serious questions have been raised about the project's need and viability, the Board cannot conclude that the Railway would carry out the Rail Policies, and thus the exemption should be denied. At a minimum, the Board should gather and evaluate additional information regarding the project's need and viability in a new weighing analysis for the proposed action, or more appropriately, in a full application proceeding, because such a proceeding is "necessary to carry out the transportation policy of section 10101," *see* 49 U.S.C.

§ 10502(a)(1). A full application proceeding would require detailed disclosure of the project's financing mechanisms, construction costs, and projected net income per 49 U.S.C. § 1150.6—exactly the information the Board needs to properly consider the relevant Rail Policies.

A. Because the Limited Financial Information Provided Raises Serious Questions about the Railway's Financial Viability, the Board Should Require a Full Application.

At the outset, the Board must deny Seven County's request that it "explicitly reject" the D.C. Circuit's holding requiring the Board to address the Railway's financial viability. Mtn. at 24. The D.C. Circuit's decision is the law of the case, and its holdings are controlling on the Board. "The law of the case doctrine precludes a reexamination in subsequent judicial or administrative proceedings of issues of law decided on appeal, explicitly or by necessary implication." *Wisc. Dept. of Transp. and E. Wisc. Cntys. R. Consortium—Petition for Declaratory Order—Common Carrier Status of Certain Operations in the State of Wisc.*, STB Docket No. FD 32717, 1997 STB LEXIS 393 at 5 n.8 (Nov. 25, 1997). *Cf. Indep. Petroleum Ass'n of Am. v. Babbitt*, 235 F.3d 588, 596-97 (D.C. Cir. 2001) ("Under the mandate rule, an inferior court has no power or authority to deviate from the mandate issued by an appellate court." (citation omitted)).

Serious questions going to the project's financial viability existing before the Board's authorization of the Railway, and numerous others arising since then, require full application proceedings. The Board has long held that assessing the project's financial viability and the applicant's fitness are key components of its analysis of the Rail Policies:

> We first look at the financial condition of the applicant and the financial feasibility of the project. Our purpose in doing so is not to protect the applicant or those who choose to invest in the proposed project. Rather it is to protect (1) existing shippers from financial decisions that could jeopardize the carrier's ability to carry out its common carrier obligation to serve them and (2) the affected communities from needless disruptions and environmental impacts if the

> applicant were to start construction but not be able to complete the project and provide the proposed service.

Tongue River Railroad Company, Inc.—Construction and Operation—Western Alignment, STB Docket No. FD 30186, 2007 STB LEXIS 584 (decided Oct. 5, 2007) at *25-*26 (footnotes omitted).[30]

While Seven County contends that the marketplace, and not the Board, will make the ultimate decision as to whether a project will be built (an assumption we dispute, *infra* at 58-60), the Board has held that "accurate financial information" is "essential" to its Rail Policy deliberations. *Great Lakes Basin Transportation, Inc.—Rail Construction and Operation—in Rock County, Wisc., Winnebago, Ogle, Lee, Lasalle, Grundy, and Kankakee Counties, Ill., and Lake, Porter, and Laporte Counties, Ind.*, STB Docket No. FD 35952, 2017 STB LEXIS 157 (decided Aug. 30, 2017) at *9 (emphasis added). In *Great Lakes Basin Transportation*, the Board found "[t]he financial information provided … is fundamentally flawed." *Id*. at *9. "The financial information submitted by GLBT … cannot reasonably be relied upon by the Board to determine the financial condition of the applicant under the statutory criteria." *Id*. at *10. As a result, the Board rejected the application for the construction of a new line. *Id*. Seven County does not even attempt to distinguish this decision.

Similarly, in *Texas Central Railroad and Infrastructure, Inc. & Texas Central Railroad, LLC—Petition for Exemption—Passenger Rail Line between Dallas and Houston, Tex.*, STB Docket No. FD 36025, 2019 STB LEXIS 181 (decided June 20, 2019), project proponents argued that "the Board should reject objections to rail construction projects based upon the lack

[30] Although this case and *Great Lakes* (discussed in the following paragraph) concern the issuance of a construction and operation license under full application procedures, the reasoning in both cases "still ha[ve] force when considering the language of the fourth and fifth Rail Policies" for an exemption. *Eagle County*, 82 F.4th at 1193.

of finalized financing arrangements, arguing that the ultimate determination of the financial feasibility of a project will be made by the financial markets." *Id*. at *12. The Board dismissed this argument:

> [I]n light of the questions raised in the current record, the Board notes that an application process may be necessary to carry out the rail transportation policy of § 10101…. An application here would provide the Board with additional information pertaining to the financial condition of the applicant and financial feasibility of the project that would assist the Board in considering the transportation merits of the project.

Id. at *13-*14. Accordingly, the Board required the proponent to submit additional information "in light of questions surrounding the financial feasibility of the proposed rail project," *id*. at *7, concerning "increasing cost of the proposed project"—from over $10 billion to $16.5 billion, or an increase of 65%—and "funding sources for these costs, including the potential pursuit of public financing," *id*. at *10-11. Given the need for additional information concerning these issues, the Board denied the petition for exemption, but granted a petition to reopen. *Tex. Cent. R.R. & Infrastructure, Inc. & Tex. Cent. R.R., LLC—Pet. For Exemption—Passenger R. Line Between Dall. & Hous., Tex*., STB Docket No. FD 36025, 2020 STB LEXIS 262, *23, *25 (July 16, 2020).

This line of Board decisions, the D.C. Circuit held, showed that: "Despite its protestations to the contrary, the Board cannot ignore and, in the past, has not ignored serious concerns about financial viability in determining the transportation merits of a project." *Eagle County*, 82 F.4th at 1193. The D.C. Circuit explained: "At bottom, a project that is in doubt of ever materializing or continuing to operate cannot accomplish any of the transportation merits identified by the Board." *Id*.

The facts at issue here are similar to those in the *Great Lakes Basin* and the *Texas Central* decisions and require a similar result. Here, the financial data the Railway has provided or is

otherwise available is similarly "fundamentally flawed" and out of date, indicates costs have potentially nearly tripled in the eight years since the only feasibility study was prepared, and demonstrates that proponents rely almost exclusively on what is now a non-existent funding source. As in the *Great Lakes* and *Texas Central* cases, the Board cannot conclude based on this data that the project will be consistent with the Rail Policies meant to ensure the Railway will not become a partially-completed or non-operational stranded asset burdening communities it purports to serve. Questions regarding the project's financing, financial feasibility, and projected costs raise significant concerns about whether this project would carry out the Rail Policies or harm the public interest.

1. The planned financing scheme is currently unavailable.

First, the financing mechanism that the Coalition tells the Board that it intends to rely on is currently unavailable, and demonstrates that, as in *Great Lakes Basin Transportation*, "[t]he financial information provided" "is fundamentally flawed." Seven County states that it intends to rely on private activity bonds, which are a taxpayer-subsidized bond, to finance most of the Railway. Mtn. at 26; Seven County Infrastructure Coalition, Utah, Inducement Resolution, Private Activity Bonds (May 8, 2025), attached as Ex. 39.[31] As an initial matter, it is highly questionable that the Railway is a "qualified highway or surface freight transfer facilit[y]" eligible for private activity bond authorization. *See* 26 U.S.C. §142(m)(2)(C). Qualified projects are limited to:

> (A) any surface transportation project which receives Federal assistance under title 23, United States Code (as in effect on the date of the enactment of this subsection),

[31] Available at https://scic-utah.org/wp-content/uploads/2025/06/Approved-and-Signed-Resolution-2025-05A-1.pdf.

> (B) any project for an international bridge or tunnel for which an international entity authorized under Federal or State law is responsible and which receives Federal assistance under title 23, United States Code (as so in effect), or
>
> (C) any facility for the transfer of freight from truck to rail or rail to truck (including any temporary storage facilities directly related to such transfers) which receives Federal assistance under either title 23 or title 49, United States Code (as so in effect).

42 U.S.C. § 142(m)(1).

Seven County has presented no evidence that the Railway receives title 23 or title 49 assistance or will receive such assistance. And as a railway, it is not an "international bridge or tunnel" or a "facility for the transfer of freight from truck to rail or rail to truck." *Id*.; *see also* Final EIS at 2-2 (Railway proposal does not include construction of terminals).

Even assuming the Railway qualifies for private activity bonds, the U.S. Department of Transportation (DOT) *has already allocated all $30 billion in private activity bonding allowed under the Tax Code*, *id*. §142(m)(2)(A), (C), leaving none available for the Railway. *See* U.S. DOT, Private Activity Bonds website (last updated Dec. 10, 2025), attached as Ex. 40.[32] Seven County's assertion that "it expects to receive U.S. Department of Transportation approval soon" to issue billions in private activity bonds, Mtn. at 26, relying on Mr. Heaton's statement (at ¶¶ 6-7), is contradicted by publicly available DOT data. DOT's website tracking Private Activity Bond authorizations states that, as of November 1, 2025, the total amount "currently available to be allocated" is "$0," leaving $0 available for the Railway. DOT website (Ex. 40). Because DOT is currently prohibited by law from allocating further private activity bonds for any project, Seven County has no basis for counting on this source of financing. While Congress could at some future date increase the allocation, that is utterly speculative. Seven County's purported source of funding is, for now, a mirage.

[32] Available at https://www.transportation.gov/buildamerica/financing/private-activity-bonds.

Realizing that this source of funding may be unavailable, Seven County is apparently seeking yet *another* public subsidy (albeit one they did not reveal to the Board): a low-interest federal loan via the U.S DOT's "Railroad Rehabilitation and Improvement Financing" (RRIF) program. Seven County's executive director Mr. Heaton reported in October 2025 that "Drexel Hamilton Infrastructure Partners [Seven County's private partner], are exploring the option of applying for a federal loan, since there is a shortage of private activity bonds." Seven County Infrastructure Coalition, Meeting Minutes (Oct. 9, 2025) attached as Ex. 41.[33] The Railway submitted a draft letter of interest to the RRIF program in November 2025 seeking a $2.8 billion loan. U.S. DOT, Build America Bureau Credit Assistance Pipeline (Jan. 1, 2026) at 3, attached as Ex. 42.[34]

2. The project's financial feasibility is unsupported.

Second, the financial data provided to the Board, and which the Board relied on, is "fundamentally flawed" and outdated. The Board relied primarily on two pieces of data: the R.L. Banks 2018 study provided by Seven County, and a few supporting letters. *Seven County Infrastructure Coalition--Rail Construction & Operation Exemption--In Utah, Carbon, Duchesne, And Uintah Counties, Utah*, STB Docket No. FD 36284, 2021 STB LEXIS 1 at *11 (Jan. 5, 2021).

The Board's January 5, 2021 preliminary exemption decision dismissed questions about financial viability based on the fact that "the Coalition asked R.L. Banks to prepare a detailed 2018 feasibility study addressing the viability of the line," and that the "Utah Petroleum Association, Enefit Oil Company, Utah Royalty Owners Association, National Oil Shale

[33] Available at https://scic-utah.org/wp-content/uploads/2025/10/10-9-25-Meeting-Minutes-APPROVED.pdf.
[34] Available at https://www.transportation.gov/sites/buildamerica.dot.gov/files/2025-12/January%202026%20Pipeline%20List.pdf.

Association, and Western Energy Alliance have expressed support for the project." *Id*. The Board concluded "[s]uch support, and the information submitted in this record, indicates the proposed line could be viable." *Id*. *See also* Mtn. at 25 (distinguishing *Texas Central* by arguing that "the Coalition answered questions about financial viability by submitting a feasibility study and by showing support from the rail line's likely customers.").

But the R.L. Banks study is "fundamentally flawed" and outdated for numerous reasons. As an initial matter, it does not describe the Railway's current proposed route, so the cost estimates are clearly wrong. R.L. Banks & Assocs., *Pre-Feasibility Study of a Prospective Railroad Connecting the Uinta Basin to the National Rail Network* at 6 (Aug. 9, 2018) (Map 1-1), attached as Ex. 43 (analyzing easterly routes going through Colorado, not current route to Kyune, Utah). The Banks study itself identified numerous concerns regarding the financial viability of the Railway, and explicitly calls out "significant potential challenges to the achievement of the projected [railcar traffic] volumes" and "associated revenue volumes." *See id*.. at 14. Many of these challenges have now borne out.

For example, the Banks study noted the potential that "a significant and long-term downturn in the price of [West Texas Intermediate (WTI) oil], particularly in the early years of the prospective railroad, could result in significant short-falls" of rail traffic. *Id*. The WTI industry benchmark has been on a long-term decline since 2022 and is now at its lowest level since the pandemic,[35] exactly the outcome the Banks study concluded could render the Railway non-viable. Macrotrends, *WTI Crude Oil Prices - 10 Year Daily Chart*, retrieved Jan. 10, 2026, attached as Ex. 44.

[35] Available at https://www.macrotrends.net/2516/wti-crude-oil-prices-10-year-daily-chart.

The Banks study also expressed concern that "prospective Uinta Basin rail shippers might seek alternative 'take away' capability or divert investment dollars" elsewhere. *Id*. at 15. Since the Board prepared the Final EIS, the regional trucking system for oil has expanded dramatically by major transportation companies such as Savage Industries, Energy Transfer, and Finley Wildcat Midstream whose projected rail loading capacity now exceeds that of the Railway (350,000 bpd). *Supra* at 21-24. Given this extensive competition, there is now a ceiling on how much the Railway can charge for the short rail haul to the main line. The major private transportation companies based in Carbon County, Utah will fight to maintain their market share versus a speculative railroad loading operation in Duchesne County.

Perhaps most significantly, the Banks study flagged that regional producers could have "[r]eluctance to [c]ommit" to the railroad, in light of other available transportation options. Banks (Ex. 43) at 15. That reluctance is now real. In March 2023, the Utah Petroleum Association (UPA) made clear that neither UPA nor its members "are involved in the new financing effort for this private venture to tap into public bonding;" stated that the Railway "must not be solely dependent upon transportation of crude oil;" and expressed producers' unwillingness to commit to using the Railway to transport oil unless it was competitive with existing transportation options:

> If constructed, the Uinta Basin Railway will add another transportation alternative to the existing options, the terms and conditions of which will be competitively evaluated against existing transportation options….
>
> • The major producers *cannot commit to rail yellow and black wax on the Uinta Basin Railway unless the project is able to compete financially with existing transportation alternatives already being utilized by the industry and must not result in increased gasoline prices for consumers*.

Utah Petroleum Association, UPA's position on the Uinta Basin Railway project (March 30, 2023) (emphasis added), attached as Ex. 45.[36]

The UPA's most recent statement last year is similarly non-committal: it notes "existing ample rail options along with other rail projects that have also been announced" and that producers' "potential use will be determined by the Railway's economics in the competitive free market." UPA, Statement On The Supreme Court's 8-0 Decision to Approve the Uinta Basin Railway in Ruling of Seven County Infrastructure Coalition v Eagle County, Colo. (May 2025), attached as Ex. 46.[37]

Given that the "significant potential challenges" Banks identified have all manifested themselves, and that Seven County has not obtained or provided the Board with "traffic volume and associated revenue forecasts" which Banks concluded were "absolutely essential," Banks at 14, the Banks study itself calls into question the Railway's viability.

The Banks study was also based on a number of assumptions concerning the purported Railway's financial viability, many of which have been proven false in the intervening years. First, it assumed that there would be tens of thousands of carloads of non-crude oil traffic leaving the Basin each year, and tens of thousands bringing in frac sand. *See* Banks at 16, Table 2-2 (Ex. 43). Virtually none of that traffic is likely to come to fruition now due to the projects assessed as adding to traffic being either dead or no longer along the planned route of the Railway. Dead projects include Enefit's shale oil and fly ash projects, *id*. at 21, 24-25, and "Refined Oil Products - Uintah Advantage." *Id*. at 21-22. Enefit has abandoned its oil shale lease and is

[36] Available at https://utahpetroleum.org/wp-content/uploads/2023/03/Utah-Petroleum-Association-Statement-on-Uinta-Basin-Railway-3.30.23.pdf.
[37] Available at https://utahpetroleum.org/wp-content/uploads/2025/05/UPA-Official-Statement-on-Uinta-Basin-Railway-Supreme-Court-Ruling-FINAL.pdf.

seeking to sell its real estate in the U.S. *See* T. Fitzpatrick, *Utah's hope for oil shale as a viable energy source is dealt another blow*, Salt Lake Trib. (Sep. 13, 2023) attached as Ex. 47; J. Voltri, *Eesti Energia to wrap up its US business*, Estonian Eesti Rahvusringhääling (Jan. 29, 2024), attached as Ex. 48. Uintah Advantage remains a speculative project that is yet to be built. The Banks study also assumed that certain products mined along the railway would be shipped, including sodium bicarbonate, fly ash, and gilsonite. Banks at 23-26. The re-routing of the railway to Kyune instead of to the Colorado mainline eliminated each of these potential customers. Indeed, the Board declined to address the cumulative effects of transporting any non-oil products as "speculative." Final EIS, Appx. T, at T-162 ("OEA is unaware of any specific plans by shippers of coal, natural gas, oil shale, fly ash, tar sands, or other commodities to request rail service on the proposed rail line."). It would be arbitrary for the Board to rely on Banks's assumptions about additional rail traffic to support the Railway's financial viability analysis while concluding that no such additional rail traffic was foreseeable.

With respect to "inbound" frac sand commodities that the Banks study projected would be carried on the new line, *see* Banks at 26-27, there is now decreasing need for drillers to rely on out-of-state shipments, as several frac sand mines have recently been permitted in the Basin. Utah Geological Survey, Utah Mining 2024 at 15 (2025) (identifying three producing frac sand mines in the Uinta Basin - Ramsey Hill (north of Vernal), Bundick/SM (west of Roosevelt), and Wildcat Sand's Echo Mine (also west of Roosevelt)), attached as Ex. 49.[38]

The Banks study also underestimated by a factor of ten the potential of an alternative "take-away" transport system (e.g., trucking) from expanding to compete with the Railway. The study concluded it was not "practical or reasonable" to assume that truck-to-rail transloading

[38] Available at https://ugspub.nr.utah.gov/publications/circular/c-139.pdf.

"realistically" could move the same volumes projected for rail, because historically, transloading volumes had "peaked at 32,000 [bpd]." Banks at 47. The study found "[i]ncreasing transloading volume beyond 32,000 bpd is unlikely due to: 1) the challenging, mountainous characteristics of the road connecting the Uinta Basin and the Price area; 2) hazardous driving conditions on said roads during winter months and 3) the inability to expand or improve existing roads, due to, among other factors, said roads passing through the Ashley National Forest." *Id*. Virtually all of these assumptions have been proven wrong. Approved capacity for truck-to-train loadouts is now 410,000 bpd. *Supra* at 24. The Indian Canyon Road (through the Ashley National Forest) has been and is being expanded and upgraded in part to accommodate increased truck traffic. *See* Utah Dep't of Transp., U.S. Route 191 Improved (website), attached as Ex. 50.[39] Truck loadouts were transloading an estimated 100,000 bpd as of February 2025, more than triple the volumes that the Banks study said was possible. *See* U.S. Bureau of Land Management, Wildcat Loadout Facility Right-of-Way Amendment, Environmental Assessment, Appendix B, B-1 (July 2025) (noting 2025 Uinta Basin oil production reached 182,000 bpd and existing Salt Lake City refining capacity is limited to 80,000 bpd, meaning that roughly 100,000 bpd was exported via truck-to-rail), attached as Ex. 51.[40]

In addition to the Banks study, the Board's decision cited letters of support from the Utah Petroleum Association, Enefit Oil Company, and the National Oil Shale Association. *Seven County*, 2021 STB LEXIS 1 at *11. But, again, UPA's support is highly conditional, *supra* at 50-51. Oil shale is not, and almost certainly never will be, a source of traffic of any kind, given the

[39] Available at https://udotinput.utah.gov/us191indiancanyon.
[40] Available at https://eplanning.blm.gov/public_projects/2039088/200657441/20137832/251037812/Final%20Final%20Wildcat%20EA%207.3.25.pdf.

Enefit project's collapse, and the lack of any other oil shale project in the nation, let alone Utah. Relying on these outdated letters as support for the Railway and its viability would be arbitrary.

In sum, the 2018 data the Board relied on is "fundamentally flawed" and must be updated, pursuant to the Board's policies and precedent. *See, e.g., Great Lakes Basin Transportation, Inc,* 2017 STB LEXIS 157 at *9.

3. The project's prior cost projections are no longer reliable, and up-to-date reliable projections are lacking.

The Railway's projected costs, as those in *Texas Central*, have ballooned in recent years, but Seven County has never provided the Board or the public with reasonably firm and up-to-date projections. The financing mechanism chosen by Seven County's private partners indicate the project's cost could now be nearly triple the R.L. Banks 2018 estimate of $1.3 billion. Banks (Ex. 43) at 40. In February 2023, Seven County approved a resolution to seek $1.9 billion in private activity bonds to finance the Railway. Seven County Infrastructure Coalition, Utah, Inducement Resolution, Private Activity Bonds (Feb. 9, 2023), attached as Ex. 52. Seven County's private partner (Mark Michel of Drexel Hamilton) told the Coalition at that time that up to 70% of the Railway's funding could come from private activity bonds, with the remaining capital coming from the private equity market. Seven County Infrastructure Coalition, Feb. 9, 2023 Meeting Audio at 1:14:05.[41] Thus, the total cost estimate at that time was approximately $2.7 billion, or more than double the 2018 Banks estimate. In May 2025, Seven County approved a resolution seeking to increase the total it would seek in private activity bonds to $2.4 billion, a 25% increase from the amount sought just two years earlier, reflecting continued cost increases. *See* 2025 Inducement Resolution (Ex. 39). If Drexel Hamilton still intends to finance

[41] Available at https://scic-utah.org/wp-content/uploads/2023/01/Coalition-Board-Meeting-2.9.23.mp3.

the project 70% with public-subsidized private activity bonds, the Railway's cost could now exceed $3.4 billion, or more than 2.6 times Banks's 2018 cost estimate. Just six months after seeking $2.4 billion in private activity bonds, the Railway submitted a draft letter of interest pursuing nearly 20% more – $2.8 billion – in federal loans, underscoring the Railways ever-inflating costs. *See* 2026 Build America Bureau Credit Assistance Pipeline (Ex. 42).

These massive increases in cost estimates are the type that have triggered the Board to require the applicant to submit additional information. *Tex. Cent. R.R. & Infrastructure, Inc. & Tex. Cent. R.R., LLC—Pet. For Exemption—Passenger R. Line Between Dall. & Hous., Tex*., FD36025, 2020 STB LEXIS 262, *23, *25 (July 16, 2020) (requiring additional financial information where the initial cost estimate for the project had doubled, if not tripled, *id*. at *22 n.24, and proponents were seeking public funding, *id* at *24 n.27. The last (and only) construction cost estimate Seven County presented to the Board is the 2018 Banks study which predated the Board's decision requiring mitigation. The Board should require Seven County to submit an updated cost projection, including the costs of mitigation required by the Board. This information is necessary to ensure that the Railway can comply with all mitigation requirements. If Seven County does not have sufficient funding to cover these costs, then it is less likely to be able to implement the project with the required mitigation measures, and more likely to abandon a project half-built. The Board cannot ensure that the Railway will fulfill the policy goals of "public health and safety," or deliver on its transportation benefits, if it cannot ensure the Railway can pay for and complete the required mitigation.

In sum, as in the *Great Lakes* and *Texas Central* cases, the Board cannot conclude based on the proffered data that the Railway will comply with the Rail Policies meant to ensure the Railway will not become a partially-completed stranded asset burdening communities it

purportedly will serve. Based on this new information, the Board should reject the Railway's exemption request and require the Seven County to provide additional financial data in a full application proceeding. A full application proceeding would ensure that the public is not saddled with significant harms and costs of a rail that is unlikely to deliver on promised benefits. *See N. Plains Res. Council, Inc. v. Surface Transp. Bd*., 668 F.3d 1067, 1092 (9th Cir. 2011) (Board considers, among other things, whether the applicant is fit, financially and otherwise, to undertake the construction and provide rail service, and whether there is a public demand or need for the service); *N.M. Navajo Ranchers Ass'n v. I.C.C.*, 702 F.2d 227, 230, 232 (D.C. Cir. 1983) (noting full application entails consideration of "whether construction of the line is in the public interest" or "would subject the communities directly affected to serious injury"). Alternatively, the Board must consider this data before the Board can weigh the project's transportation merits and environmental harms. *Ozark Mountain Railroad* ("*Ozark I*"), 1994 ICC LEXIS 271, ICC Finance Docket No. 32204, at *2, *4 (ICC served Nov. 22, 1994) (noting Board's requiring applicant to submit additional financial information to determine whether an application should be required, which led to Board revoking conditional approval and requiring application); *Ozark Mountain Railroad* ("*Ozark II*"), 1995 ICC LEXIS 248, ICC Finance Docket No. 32204, at *8 (Sept. 7, 1995) (affirming that Board "may require the submission of additional information in rail exemption proceedings if the impact of the proposed exemption cannot be readily ascertained from the information contained in the petition, or if significant adverse impacts might occur if the proposed exemption were granted").

B. Seven County's Invitation for the Board to Forego Analysis of the Project's Financial Viability Is Contrary to the Rail Policies and Not Supported by the Facts.

Seven County asks the Board to flout the D.C. Circuit's decision and to overrule the Board's prior precedent, establishing a "new rule" that a project's financial viability is irrelevant

to the Rail Policies. Mtn. at 24-26. The Board should reject this unprecedented and unlawful approach. Such a rule would effectively abandon the Board's responsibilities to weigh the Rail Policies, contrary to ICCTA. Seven County is also incorrect that the Railway's construction will be decided by the market. Rather, the project is driven by a public applicant, not industry, and is heavily reliant on public subsidies. Seven County's request that the Board need not inquire into the Railway's viability, because the market will make that assessment, is inappropriate given these circumstances.

1. Seven County's proposed rule runs contrary to ICCTA.

Seven County fails to explain how a rule abandoning financial viability considerations is consistent with the Board's obligations to consider the rail policies and to balance the transportation merits against the environmental harms under 49 U.S.C. § 10101. Seven County suggests that financial viability has no place in the transportation merits analysis, because "[a] policy favoring 'development' of the rail system—including construction of new rail lines—must favor an uncertain new project that would bring 'effective competition' over no project at all." Mtn. at 24 (citing 49 U.S.C. § 10101(4)). That oversimplifies the Board's ICCTA duties. Those duties go beyond only facilitating the construction of new railroads. As Seven County concedes, before the Board approves an exemption, it must weigh a project's transportation merits against its environmental consequences. *See id*. at 30. A significant relevant factor in this weighing analysis that the Board has long recognized, but Seven County ignores, is the risk that the project construction results in a stranded asset that causes lasting environmental damage, with none of the claimed transportation benefits materializing for shippers or the public. *Tongue River*, 2007 STB LEXIS 584 at *26; *N. Plains Res. Council*, 668 F.3d at 1093 (Board's duties require considering whether the "building of unnecessary lines involves a waste of resources, and that

the burden of this waste may fall upon the public") (citing *Texas & P. Ry. Co*., 270 U.S. at 277)). The Board should reject Seven County's overly narrow reading of the Rail Policies.

Seven County also claims that "proving the financial viability of a project depends in part on its receiving Board approval," so financial viability will "often" be "hard to answer" before the Board approves a project. Mtn. at 25. No evidence supports this claim, and it defies common sense. Industry actors routinely calculate financial risks, with or without available financing, based on their own assessment of a project's financial viability, despite the uncertain outcome of a permitting application. Regardless, the D.C. Circuit did not require that Seven County "prov[e]" the railway's financial viability. It simply held that the Board "cannot ignore … serious concerns about financial viability in determining the transportation merits of a project." *Eagle County*, 82 F.4th at 1193. Turning a blind eye to serious financial concerns would be an abdication of the Board's duties to uphold the Rail Policies.

2. The project is not in the hands of the marketplace.

The change in policy pushed by Seven County is not only unlawful, it cannot apply to the circumstances of this case. Financial viability considerations require closer scrutiny here because, contrary to Seven County's assertions, the "marketplace" is not driving this project. Unelected public officials and public subsidies are. Although the project's purpose is to serve a single industry, the primary driver of this project is the project applicant and public entity Seven County, not private industry.

So far, Seven County has almost entirely financed the project using a $27.9 million grant from Utah's Community Impact Board to fund railroad design, technical studies, environmental reviews, permitting, and litigation. Office of the Legislative Auditor General, State of Utah, Report to the Utah Legislature, No. 2020-03, A Performance Audit of the Permanent Community

Impact Fund (May 2020), 12-13, 50.[42] Seven County took on the project and requested public funds because *industry would not pursue the project on its own*. In 2018, Seven County's attorney was quoted as saying: "Rail is viable, however, not at a rate of return that would entice private industry. Therefore, it would be appropriate for a public body to proceed with the Rail project." Seven County Infrastructure Coalition, Meeting Minutes (Oct. 11, 2018) at 3, attached as Ex. 53.[43] Strikingly, even after this major investment of public funds, no major national oil company nor any of the crude oil producers in the Uinta Basin has stepped up to invest in the Railway. *Supra* at 50-51.[44] And the Railway's planned operator—Rio Grande Pacific—quietly withdrew from the project in 2023. D. Williams, *Texas rail company eyeing Colorado passenger service no longer involved with Utah oil trains*, Rocky Mountain Post (Nov. 15, 2024), attached as Ex. 54.[45] More than two years later, Seven County has not identified a new operator.

More strikingly, Seven County's own private partner has so far shielded itself from the project's financial risk. Seven County is apparently paying all major Railway costs, including engineering and bond attorney's fees—Drexel Hamilton would reimburse Seven County *only* "if the [private activity] bond issuance goes through." Seven County Infrastructure Coalition, May 8, 2025 Meeting Audio at 1:10:15-1:11:49.[46]

The lack of private investment apparently requires Seven County to apply for private activity bonds to finance the project. *Supra* at 54-55. Private activity bonds are tax-exempt

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[42] Available at https://le.utah.gov/interim/2020/pdf/00003384.pdf.
[43] Available at https://scic-utah.org/public-meetings/2018-meeting-archive/.
[44] The lack of private investment in the Railway stands in contrast to the flurry of private development in truck-to-rail transloading facilities.
[45] Available at https://www.rockymountainpost.com/texas-rail-company-eyeing-colorado-passenger-service-no-longer-involved-with-utah-oil-trains/.
[46] Available at https://scic-utah.org/wp-content/uploads/2025/05/Coalition-Board-Meeting-5.8.25.mp3.

bonds— subsidized by taxpayers—specifically designed to attract private investment in federally funded transportation projects. Ex. 40 (DOT, Private Activity Bonds website, explaining that "[p]roviding private sector infrastructure developers and operators with access to tax-exempt debt lowers the cost of capital for these large and expensive projects, enhancing their investment prospects."). And as a back-up, if that public-subsidized bond application fails, Seven County is taking steps to apply for a massive public-subsidized low-interest loan via the RRIF program. *Supra* at 48. "The ultimate decision to go forward with an approved project" here would not just be "in the hands of the applicant and the financial marketplace," as Seven County claims, Mtn. at 24-25, but in the hands of public officials seeking out, and doling out, public subsidies.

That industry has so far not pursued the project, the public has assumed all the risk, and taxpayers must subsidize Seven County to complete the project, should trigger closer Board scrutiny of the project need and viability. Like in *Texas Central R.R. & Infrastructure, Inc.*, 2019 STB LEXIS 181, at *5-6, Seven County's "pursuit of public financing" and taxpayer subsidies justifies an inquiry into whether an application is required to carry out the Rail Policies. Indeed, the rule that Seven County now requests should apply to this case is only appropriate in cases involving "private *rather than government funding*." *California High Speed Rail, supra*, at *20 (emphasis added).

Because public officials and public subsidies are the driving force enabling the project—not industry or the financial markets—it would be improper for the Board to abandon its responsibility to address serious questions concerning the Railway's viability.

C. On Remand, the Board Must Address the "Environmental Policies," Including Its Duty to Protect "Public Health and Safety" and to Address "Energy Conservation."

As described above, the Board's duty to address "public health and safety" encompasses environmental impacts. The D.C. Circuit held that the Board failed to address environmental

policies by simply pointing to its flawed EIS. *Eagle County*, 82 F.4th at 1194-96. As noted above, the Supreme Court did not address numerous flaws that the D.C. Circuit identified, especially those related to public health and safety, i.e., oil spills, train accidents, and fires.

On remand, the Board must heed the D.C. Circuit's holding that "[t]he Board is required to compare both sides of the ledger," including the environmental costs to which the Board gave only "limited weigh[t]." *Id.* at 1195.

1. The Board must address the Railway's energy conservation impacts.

The Court found that the Board "did not evaluate the energy conservation policy," although the Rail Policy directs the Board "to encourage and promote energy conservation." *Id*. at 1194; *see* 49 U.S.C. § 10101(14). Seven County alleges that the Board may conclude that the construction of a new rail line will fulfill the "energy conservation" policy by "supporting truck-to-rail diversions" that "increase energy efficiency across modes." Mtn. at 27. But there is no evidence that those trucking oil will switch to rail transport. The Utah Petroleum Association warned that they may not be interested unless the price is right, so if the Railway provides a more expensive option than trucking, no energy conservation policy will be served, and a huge amount of resources, including fuel and other energy resources, may be wasted on rail construction.

The Board decision Seven County cites, *Savannah Indus. Transp., LLC – Construction Exemption – In Effingham Cnty., Ga.*, STB Docket No. FD 36723, 2025 WL 2234811, at *4 (STB decided Aug. 4, 2025), involved a previously constructed rail line where the Board had evidence the line was already moving traffic that would otherwise move by truck. The EA for the project included an analysis of energy saved by train trips displacing truck trips. Surface Transp. Bd., Draft Environmental Assessment, Savannah Industrial Logistics, Docket Nos. FD 36723 and FD 36723 (Sub-No. 1) (Apr. 2025) at 22, attached as Ex. 55. *See also, e.g., DesertXpress*

Enterprises, LLC, and DesertXpress HSR Corporation--Construction and Operation Exemption--in Victorville, Cal., and Las Vegas, Nev., STB Docket No. FD 35544, 2023 STB LEXIS 215 at *8 (STB served Nov. 15, 2023) (decision addressing energy conservation based on estimates that rail travel would remove "over 700 million vehicle miles traveled" by car, and noting the "far lower emissions associated with rail.")

The EIS here assumed that train trips would displace trucks moving oil from the Basin, resulting in energy savings. *Supra* at 25 n.18. New information regarding producers' preference for trucking, and the lack of any financial information showing that rail will be more price competitive than trucking throws this assumption into doubt. The only "evidence" Seven County provides to support its assumption that the Railway would displace truck traffic is Mr. Heaton's conclusory "statement." Mtn. at 27 (citing Heaton Statement at ¶¶ 11-12). As with most of his other contentions, Mr. Heaton's assertion, that "[o]ne of the key benefits of the Uinta Basin Railway is that it will greatly reduce the number of tanker trucks on public roads," is vague, unquantified, and unsupported. It is also contradicted by UPA's statements asserting that oil producers will use the *cheapest* transport method available, including trucks to the maximum extent, whether or not that conserves energy. *Supra* at 50-51.

Given new information about truck traffic moving oil to the Union Pacific Line and utilizing rail transloading facilities there, the Board cannot credit Mr. Heaton's assertions without analysis, which the Board must undertake on remand to address whether the Railway will in fact "encourage and promote energy conservation."

2. The Board must address the Railway's "public health and safety" impacts.

The D.C. Circuit's decision requires the Board to address the public health and safety impacts, including harms from derailment, spills, fires, and other harms related to accidents.

Supra at 5-20. This the Board failed to do. On remand it must do so to comply both with NEPA and with its duty to address and uphold the Rail Policy to "operate transportation facilities and equipment without detriment to the public health and safety," 49 U.S.C. § 10101(8).

3. The Board must address whether the Railway's transportation "benefits" outweigh its environmental harms.

Seven County would have this Board effectively eliminate any weighing of environmental harms the Railway threatens based on ICCTA's "permissive licensing standard" that accepts new rail construction projects as being "in the public interest unless shown otherwise." Mtn. at 31, quoting *Alaska R.R. Corp. – Construction & Operation Exemption – Rail Line Extension to Port MacKenzie, Alaska*, STB Docket No. FD 35095, 2011 WL 5857339, at *4 (STB decided Nov. 17, 2011)).

But presumptions are always rebuttable, meaning that the Board cannot ignore environmental harms. Those harms are many and great, especially in Colorado, where oil train traffic along the Colorado River would threaten the livelihoods of farmers, ranchers, and tourism operators, and the health and safety of local communities and 40 million western U.S. residents who depend on the river for their drinking water.

And given that it is now unclear whether the Railway will move any oil out of the Basin, based on competition with truck-to-rail transloading facilities, there may be no transportation benefits at all. Rather, there is a significant risk that Utah communities will be left bearing the costs of addressing a half-built railroad or stranded asset, and the legacy effects of destabilized soils and slopes, runoff pollution, habitat fragmentation, and damage to public lands, streams, and wetlands. Development of the Railway would involve:

- construction on steep slopes, creating landslide, debris flow, and rockslide hazards, and within seismic areas susceptible to induced liquefaction, Final EIS at 3.5-20-22, 3.5-25-26;

- construction of 30 rail bridges and one road bridge, and blasting and mining for five tunnels totaling 5.7 miles through mountainous terrain, BiOp, EI-31295 (Sept. 20, 2021) at 7; Final EIS at 2-32;

- disruption of Argyle Canyon communities due to displacement of homes and loss of home values, *id*. at 3.13-15-19;

- elimination of hundreds of acres of habitat for the federally listed Barneby Ridge-cress, Pariette cactus, Uinta Basin hookless cactus, and Ute ladies'-tresses, *id*. at S-17, 3.4-19, 56;

- loss of six leks (or mating grounds) for the Emma Park sage-grouse population and potential extirpation of this highly sensitive population, *id*. at 3.4-45-46, 3.4-61-62;

- destruction and loss of crucial habitat for big game species and disruption of their migratory routes, *id*. at 3.4-50;

- tunnelling 423 stream crossings and rechanneling and filling 3.8 miles of streams, BiOp at 7;

- permanent loss and degradation of dozens of acres of wetlands and hundreds of acres of floodplains, *id*. at 2-39; and

- loss of nearly 400 acres of inventoried roadless areas along 12 miles of the Ashley National Forest, *id*. at 2-44.

Even if there are economic benefits to out-of-state oil companies, and to some of the small number of persons residing in the Uinta Basin, far more Utahns and Coloradans will be harmed from increased air and water pollution and accident risks. On balance, the Railway will not "improve [those] lives." *See* Mtn. at 32. Nor will the potentially massive increase in climate pollution the Board itself predicted the Railway will cause – up to 53 million tons of CO2 equivalent per year – "improve lives." *See* Final EIS at 3.15-36. To the extent that Seven County alleges that the Final EIS greenhouse gas analysis "is wrong," Mtn. at 32 n.6, that does not support the Board rubber-stamping its analysis on remand.

CONCLUSION

For the reasons set forth above, the Board on remand should:

(1) Deny SCIC's exemption request based on its misleading and outdated financial information and require a full application proceeding under 49 U.S.C. § 10901 for the collection and evaluation of financial data, or, at a minimum, require SCIC to provide additional data;

(2) Prepare a supplemental EIS to address errors and omissions in its initial review, including its failure to address the potential harm from spills, leaks, accidents, and fires along the Colorado River;

(3) Address significant new information, including:

- The construction and use of new oil loadouts;
- New information concerning the increased risk of longer, heavier, and loaded unit trains as proposed by the Railway;

(4) Prepare a new biological assessment that addresses the impact of potential oil spills into and impacting critical habitat for threatened and endangered fish in the Colorado River, as required by the Endangered Species Act; and

(5) Address the Railway's compliance with Rail Policies, including the Board's duty to protect "public health and safety," to address "energy conservation," and to weigh the environmental harms against the alleged transportation benefits.

Respectfully submitted January 12, 2026,

/s/ Wendy Park

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CERTIFICATE OF SERVICE

I certify that on January 12, 2026, I caused a copy of the foregoing document and attached exhibits to be served by email upon all parties of record in this proceeding.

/s/ Wendy Park
Wendy Park

Dated: January 12, 2026

TABLE OF EXHIBITS

Exhibit 1. *Seven County v. Eagle County*, Oral Argument Transcript at 68-69 (U.S. Dec. 10, 2024)

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EXHIBIT 1

SUPREME COURT
OF THE UNITED STATES

IN THE SUPREME COURT OF THE UNITED STATES

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SEVEN COUNTY INFRASTRUCTURE)
COALITION, ET AL.,)
Petitioners,)
v.) No. 23-975
EAGLE COUNTY, COLORADO, ET AL.,)
Respondents.)

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Pages: 1 through 118

Place: Washington, D.C.

Date: December 10, 2024

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Washington, D.C.

Tuesday, December 10, 2024

The above-entitled matter came on for oral argument before the Supreme Court of the United States at 10:09 a.m.

APPEARANCES:

PAUL D. CLEMENT, ESQUIRE, Alexandria, Virginia; on behalf of the Petitioners.

EDWIN S. KNEEDLER, Deputy Solicitor General, Department of Justice, Washington, D.C.; on behalf of the Federal Respondents, supporting the Petitioners.

WILLIAM M. JAY, ESQUIRE, Washington, D.C.; on behalf of Respondents Eagle County, et al.

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JUSTICE SOTOMAYOR: What do you understand to be -- the issue before us? There were a lot of decisions by the court below, at least five that I'm aware of. One was on sending it back for the railroad to consider the additional oil production in the basin and the other that the railroad would spur oil refining in Texas and Louisiana. Our -- and the -- your brief was limited to those two issues.

MR. KNEEDLER: That -- that's what we focused on because we didn't understand the question presented to cover the -- the downline effects.

JUSTICE SOTOMAYOR: Neither did I when I read the cert petition.

But, having said that, because they don't mention the other things, the -- the -- the wildfires, the railroad accidents, or the Colorado River impact, you don't think those issues are before us?

MR. KNEEDLER: I -- I -- I don't think -- no, I don't think that they are before you. And the precise issue, I think, before the Court with respect to both the oil and gas development and the -- and the refineries is

whether what the -- was it arbitrary and capricious for the agency not to have done more?

On both ends of that, it identified the aggregate. It identified a low and high range of how much oil would be produced based on the capacity of -- of the rail line and -- and the aggregate amount of -- of emissions that would happen in Louisiana.

JUSTICE SOTOMAYOR: So just so I'm clear, the other items, the wildfires, the accidents, and Colorado River, were not mentioned in the cert petition?

MR. KNEEDLER: I -- I -- no, I don't -- I -- I don't believe -- and -- but, no, the agency obviously did evaluate those along the 88 miles. The question is whether it -- whether had -- and it did evaluate those things downline. This is an example of -- of fly-specking because the Respondents said, well, they should have done a little more. They should have done a little more.

JUSTICE SOTOMAYOR: Thank you, counsel.

CHIEF JUSTICE ROBERTS: Justice Kagan?

Justice Kavanaugh?

EXHIBIT 2

U.S. Department of Transportation

Pipeline and Hazardous Materials
Safety Administration
Washington, D.C. 20590

Final Regulatory Impact Analysis

[Docket No. PHMSA-2012-0082] (HM-251)

Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains;

Final Rule

Office of Hazardous Material Safety

May 2015

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I. Executive Summary

The Pipeline and Hazardous Materials Safety Administration (PHMSA) and the Federal Railroad Administration (FRA) are issuing a final rule, titled *Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for HHFTs,* in order to increase the safety of hazardous materials transported by rail. The amendments take into consideration public comments from the Advanced Notice of Proposed Rulemaking (ANPRM) and the Notice of Proposed rulemaking (NPRM) on August 1, 2014 (79 FR 45015). This final Regulatory Impact Analysis (RIA) supplements the final rule.

The final rule became necessary due to the expansion in United States (U.S.) energy production that has led to significant challenges in the transportation system. Expansion in oil production has led to increasing volumes of product transported to refineries and other transport-related facilities such as transloading facilities. Traditionally, pipelines and oceangoing tankers have delivered the vast majority of crude oil to U.S. refineries, accounting for approximately 93 percent of total receipts (in barrels) in 2012. Although other modes of transportation—rail, barge, and truck—have accounted for a relatively minor portion of crude oil shipments, volumes have been rising very rapidly. With a growing domestic supply, rail transportation, in particular, has emerged as a flexible alternative to transportation by pipeline or vessel. The volume of crude oil carried by rail increased 423 percent between 2011 and 2012.[1] [2] In 2013, the number of rail carloads of crude oil surpassed 400,000.[3] [4] Based on information from the Association of American Railroads (AAR), the U.S. Energy Information Administration (U.S. EIA) shows the amount of crude oil and refined petroleum products moved by U.S. railroads continued to increase by nine percent during the first seven months of 2014 compared with the same period in 2013. This is demonstrated by Figure ES1 below.

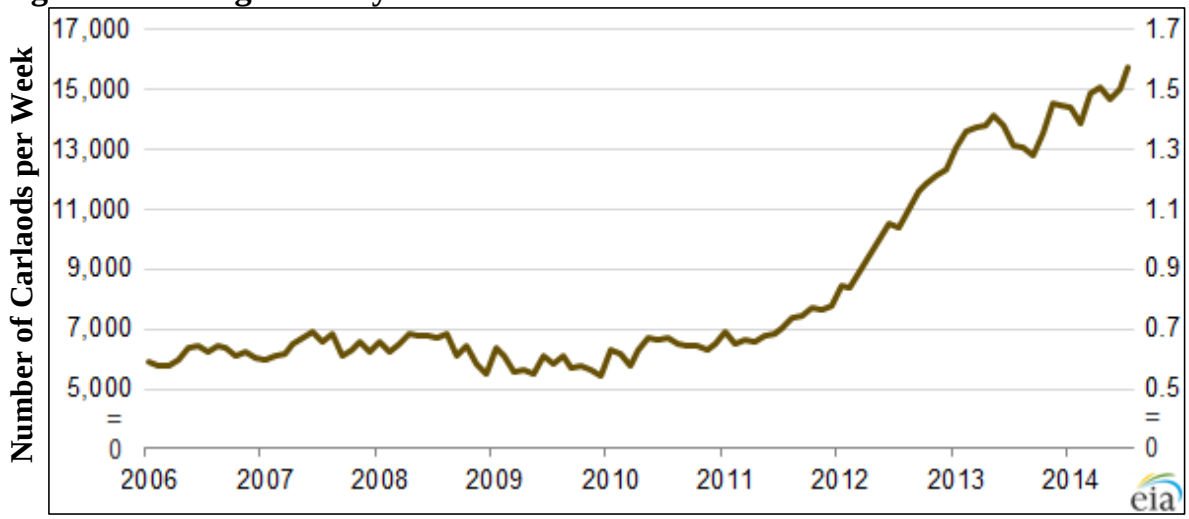
[1] See U.S. Rail Transportation of Crude Oil: Background and Issues for Congress; http://fas.org/sgp/crs/misc/R43390.pdf

[2] See Table 9 of EIA refinery report http://www.eia.gov/petroleum/refinerycapacity/ See also "Refinery receipts of crude oil by rail, truck, and barge continue to increase" http://www.eia.gov/todayinenergy/detail.cfm?id=12131

[3] http://www.stb.dot.gov/stb/industry/econ_waybill.html

[4] http://www.eia.gov/todayinenergy/detail.cfm?id=17751

Figure 1: Average Weekly U.S. Rail Carloads of Crude Oil and Petroleum Products



U.S. ethanol production has also increased considerably during the last 10 years and has generated similar growth in the transportation of ethanol by rail.[5] Ethanol constitutes 26 percent of the total number of hazmat shipments and is 1.1 percent of all railroad shipments.[6]

Approximately 68 percent of the flammable liquids transported by rail are comprised of crude oil or ethanol. While the accident *rate* has declined by 12.7% from 2005-2015, the recent increase in shipments of large quantities of flammable liquids by rail has led to an increase in the number of train accidents, posing a significant safety and environmental concern. The risk of flammability is compounded in the context of rail transportation because petroleum crude oil and ethanol are commonly shipped in large blocks or single commodity trains (unit trains). In recent years, train accidents/incidents (train accidents) involving a flammable liquid release, and resulting in fires with severe consequences, have occurred (e.g., Arcadia, OH; Plevna, MT; Casselton, ND; Aliceville, AL; Lac-Mégantic, Quebec; Lynchburg, VA).

PHMSA is revising the HMR to establish requirements for any "high-hazard flammable train" (HHFT) that is transported over the U.S. rail network. Based on analysis of the risk of differing train compositions, this rule defines an HHFT as a train comprised of 20 or more tank carloads of a Class 3 flammable liquid in a continuous block or 35 or more tank carloads of a Class 3

[5] Association of American Railroads. 2013. Railroads and Ethanol. Available online at https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Ethanol.pdf

[6] http://ethanolrfa.org/page/-/rfa-association-site/Industry%20Resources/RFA.Ethanol.Rail.Transportation.and.Safety.pdf?nocdn=1

flammable liquid across the entire train. For the purposes of advanced braking systems this rule also defines a "high-hazard flammable unit train" (HHFUT) as a train comprised of 70 or more loaded tank cars containing class 3 flammable liquids traveling at greater than 30 mph. The rule ensures that the requirements are closely aligned with the risks posed by the operation of trains that are transporting large quantities of flammable liquids. As discussed further, below, this rule primarily impacts trains transporting large quantities of ethanol and crude oil, because ethanol and crude oil are most frequently transported in high-volume shipments that when transported in a single train, would meet the definition of an HHFT. By revising the definition of HHFT as proposed in the NPRM, we have clarified the scope of the final rule and focused on the highest-risk shipments, while not affecting lower-risk trains that are not transporting similar bulk quantities of Class 3 flammable liquids.[7]

Table ES1 describes the regulatory changes implemented in the final rule and identifies affected entities.

Table ES1: Affected Entities and Requirements

Adopted Requirement	Affected Entity
<u>Enhanced Standards for Both New and Existing Tank Cars Used in HHFTs</u> • New tank cars constructed after October 1, 2015 are required to meet enhanced DOT Specification 117 design or performance criteria. • Existing tank cars must be retrofitted in accordance with the DOT-prescribed retrofit design or performance standard. • Retrofits must be completed based on a prescriptive retrofit schedule.	Tank Car Manufacturers, Tank Car Owners, Shippers / Offerors and Rail Carriers
<u>More Accurate Classification of Unrefined Petroleum-Based Products</u> Develop and carry out testing program for all unrefined petroleum-based products, such as crude oil, to address: • Frequency of sampling and testing that accounts for any appreciable variability of the material • Sampling prior to the initial offering of the material for transportation and when changes that may affect the properties of the material occur; • Sampling methods that ensures a representative sample of the entire mixture, as offered, is collected; • Testing methods that enable classification of the material under the HMR; • Quality control measures for sample frequencies; • Duplicate samples or equivalent measures for quality assurance; • Criteria for modifying the sampling and testing program; • Testing or other appropriate methods used to identify properties of the mixture relevant to packaging requirements	Offerors / Shippers of Unrefined Petroleum-Based Products

[7] In the August 1, 2014, NPRM an HHFT was defined as a train comprised of 20 or more carloads of a Class 3 flammable liquid. This rule defines an HHFT as a train comprised of 20 or more tank car loads of a Class 3 flammable liquid in a continuous block or 35 tank car loads of a Class 3 flammable liquid across the entire train.

Table ES1: Affected Entities and Requirements	
• Certify that program is in place, document the testing and sampling program outcomes, and make information available to DOT personnel upon request.	
<u>Rail routing - Risk assessment</u> • Perform a routing analysis that considers, at a minimum, 27 safety and security factors and select a route based on its findings. These planning requirements are prescribed in 49 CFR § 172.820. <u>Rail routing - Notification</u> • Requires railroads to notify State and/or regional fusion centers and State, local and tribal officials who contact a railroad to discuss routing decisions are provided appropriate contact information for the railroad in order to request information related to the routing of hazardous materials through their jurisdictions. This replaces the proposed requirements to notify State Emergency Response Commissions (SERCs) or other appropriate state delegated entity about the operation of these trains through their States.	Rail Carriers, Emergency Responders
<u>Reduced Operating Speeds</u> • Restrict all HHFTs to 50mph in all areas • Require HHFTs that contain any tank cars not meeting the enhanced tank car standards required by this rule operate at a 40-mph speed restriction in high-threat urban areas[8]	Rail Carriers
<u>Enhanced Braking</u> • Require HHFTs to have in place a functioning two-way end-of-train (EOT) device or a distributed power (DP) braking system. • Require trains meeting the definition of a "high-hazard flammable unit train" (HHFUT)[9] be operated with an electronically controlled pneumatic (ECP) braking system after January 1, 2021 for PG I and May 1, 2023 for all other PG.	Rail Carriers, Emergency Responders

[8] As defined the Transportation Security Administration's regulations at 49 CFR 1580.3, High- Threat Urban Area (HTUA) means an area comprising one or more cities and surrounding areas including a 10-mile buffer zone, as listed in Appendix A to 49 CFR Part 1580.

[9] A "high-hazard flammable unit train" (HHFUT) means a train comprised of 70 or more loaded tank cars containing class 3 flammable liquids traveling at greater than 30 mph.

PHMSA and FRA received over 3,200 public comments representing over 182,000 signatories in response to the August 1, 2014 NPRM and initial RIA. We carefully considered each comment and adjusted the final rule and RIA as appropriate.

This RIA adjusts the methodology used to estimate the benefits resulting from the final rule in the following ways:

1) Performed additional derailment simulations to verify tank car puncture resistance and ECP brake effectiveness
2) Re-estimated the derailment forecast in response to comments
3) Revised the crude and ethanol carload forecast based on comments to the NPRM submitted by the industry
4) Added a review of applicable literature to verify appropriateness of cost estimates for non-safety related damages from crude oil and ethanol releases
5) Scaled down the damages from Lac-Mégantic, to account for a smaller expected number of cars derailed and lower speeds in Higher-Consequence Event Damage Model

This RIA adjusts the methodology used to estimate the costs of applying the final rule in the following ways:

1) Revised the number of offerors and railroads impacted by classification and routing requirements
2) Adopted separate standards for new tank car construction requirements consistent with Option 2 of the NPRM except for the braking component and retrofit requirements for existing tank cars in accordance with Option 3 from the NPRM (excluding top fittings protection and steel grade)
3) Revised assumptions on truck upgrades and transfer of jacketed DOT-111 tank cars to oil sands
4) Revised assumption that no cars would be retired from crude and ethanol service
5) Revised and updated the tank car fleet based on consultations with Transport Canada, comments submitted to the docket by industry, and expected 2015 deliveries
6) Adjusted the estimated cost to equip tank cars with ECP brakes

Table ES2 provides a high-level overview of the adjustments made to the rulemaking from the NPRM to final rule stage based on public comment and further analysis.

Table ES2: NPRM vs. Final Rule Comparison

Topic	NPRM Proposal	Final Rule Amendment	Justification
Scope – High-Hazard Flammable Train	High-hazard flammable train means a single train carrying 20 or more carloads of a Class 3 flammable liquid.	A continuous block of 20 or more tank cars loaded with a flammable liquid or 35 or more tank cars loaded with a flammable liquid dispersed through a	PHMSA and FRA modified the proposed definition to capture the higher-risk bulk quantities transported in unit trains, while excluding lower-risk manifest trains. This revision better captures the intended trains.

Table ES2: NPRM vs. Final Rule Comparison			
Topic	**NPRM Proposal**	**Final Rule Amendment**	**Justification**
		train.	
Tank Car – New Construction	Three options for new tank car standards (See table 13)	A modified version of Tank Car Option #2 from the NPRM.	These design enhancements will reduce the consequences of accidents involving an HHFT. These enhancements will improve puncture resistance and thermal survivability. There will be fewer car punctures, fewer releases from the service equipment (top and bottom fittings). See RIA.
Tank Car – Existing Fleet	Consistent with proposed new tank car standards, the same three options for retrofitted tank car standards. It was proposed that both new and retrofitted cars would meet the same standard.	Tank Car Option #3 from the NPRM for retrofits.	Provides incremental safety benefit over the current fleet while minimizing cost. These design enhancements will reduce the consequences of a derailment of an HHFT. There will be fewer car punctures, fewer releases from the service equipment (top and bottom fittings), and delayed release of flammable liquid from the tank cars through the pressure relief devices. See RIA.
Tank Car – Retrofit Timeline	A five-year retrofit schedule based solely on packing group.	A risk-based ten-year retrofit schedule based on packing group and tank car.	Provides for greater risk reduction by focusing on the highest risk tank car designs first. Accounts for industry retrofit capacity.
Speed Restrictions	A 50 mph restriction across the board for HHFTs and three options for a 40 mph restriction in specific areas	A 50 mph restriction across the board for HHFTs and a 40 mph restriction in HTUA if the HHFT contains any cars not meeting enhanced tank car standards.	Decreases the kinetic energy involved in accidents. Adopts the most cost-effective solution and limits the impact of rail congestion.
Braking	The scaling up of braking systems culminating in ECP braking for HHFTs or a speed limitation for those not meeting the braking requirements	(1) Require HHFTs to have in place a functioning two-way EOT device or a DP braking system. (2) Require HHFUTs be operated with an ECP braking system after December 31, 2020.	Provides a two-tiered, cost-effective and risk-based solution to reduce the number of cars and energy associated with train accidents. Focuses on the highest-risk train sets.
Classification	A classification plan for mined liquids and gases	A classification plan with clarification on the materials subject to	Addresses comments seeking clarity of requirements. We expect the requirements would reduce the

Table ES2: NPRM vs. Final Rule Comparison			
Topic	**NPRM Proposal**	**Final Rule Amendment**	**Justification**
		a plan.	expected damages and ensure that materials are properly classified in accordance with the HMR.
Routing	Require railroads operating HHFTs to conduct a routing analysis considering, at a minimum, 27 factors	Require railroads operating HHFTs to conduct a routing analysis considering, at a minimum, 27 factors.	Track type, class, and maintenance schedule as well as training and skill level of crews are included in the 27 risk factors identified that need to be considered, at a minimum, in a route analysis. Evaluation of these factors could result in prevention of an accident due to either rail defects or human factors/errors.
Notification	Require trains carrying 1,000,000 gallons or more of Bakken Crude oil to notify SERCs	Use the notification portion of the routing requirements (i.e. notification to state fusion centers) to satisfy need for pertinent information.	Addresses concerns over security sensitive and confidential business information. Addresses the need for action in the form of additional communication between railroads and emergency responders to ensure that the emergency responders are aware of the appropriate contacts at railroads to discuss routing issues with.

As mentioned above, this RIA supplements the final rule and addresses the economic impacts associated with the regulatory provisions. Table ES3 shows the costs and benefits by affected section and rule provision over a 20-year period, discounted at a rate of seven percent. Table ES3 also shows an explanation of the comprehensive benefits and costs (i.e., the combined effects of individual provisions), and the estimated benefits, costs, and net benefits of each amendment.

Given the uncertainty associated with the risks of crude oil and ethanol shipments, Table ES3 contains a range of benefits estimates. To calculate the projected benefits for years 2015-2034, the PHMSA uses the U.S. safety record for crude oil and ethanol from 2006 to 2013 adjusted for the projected increase in shipment volume over the next 20 years. That projection is the "low-end" of the estimated benefit's range. To calculate the "high-end" of that benefits range, PHMSA used probabilistic risk model that produces a range of estimates associated with the projected higher-consequence events.

Table ES3. 20-Year Costs and Benefits by Stand-Alone Proposed Regulatory Amendments 2015-2034[10]			
Affected Section[11]	**Provision**	**Benefits (7%)**	**Costs (7%)**
49 CFR 172.820	Rail Routing+	Cost effective if routing were to reduce risk of an incident by 0.41%	$8.8 million
49 CFR 173.41	Classification Plan	Cost effective if this requirement reduces risk by 1.29%	$18.9 million
49 CFR 174.310	Speed Restriction: 40 mph speed limit in HTUA if the HHFT contains any cars not meeting the enhanced standards*	$56 million – $242 million**	$180 million
	Advanced Brake Signal Propagation Systems	$470.3 million - $1,114 million**	$492 million
49 CFR part 179	Existing Tank Car Retrofit/Retirement	$426 million - $1,706 million**	$1,747 million
	New Car Construction	$23.9 million - $97.4 million**	$34.8 million
Cumulative Total		$912 million-$2,905 million**	$2,482 million

"*" indicates voluntary compliance regarding crude oil trains in high-threat urban areas (HTUA)
"+" indicates voluntary actions that will be taken by shippers and railroads
"**" Indicates that the low end of the benefits range is based solely on lower consequence events, while the high end of the range includes benefits from mitigating high consequence events.

[10] All costs and benefits are in millions over 20 years, and are discounted to present value using a 7 percent rate.

[11] All affected sections of the Code of Federal Regulations (CFR) are in Title 49.

Although we analyze the effects of individual requirements separately, we have taken a system-wide approach covering all requirement areas. This approach is designed to mitigate damages of rail accidents involving flammable liquids, though some provisions could also prevent accidents. As a result, this analysis shows that expected damages based on the historical safety record could be $4.1 billion and damages from higher-consequence events could reach $12.6 billion over a 20-year period in the absence of the rule.

II. Introduction

In this final RIA, PHMSA and FRA analyze the impacts associated with a system-wide, comprehensive final rule that addresses the risk associated with the transportation of flammable liquids in HHFTs. Final rule provisions include:

1) Tank Car Specifications
2) Advanced Brake Signal Propagation Systems
3) Speed Restrictions
4) Routing and Notification Requirements
5) Classification of Unrefined Petroleum-Based Products

Flammable liquids include a wide variety of chemical products. The items listed in the Table T1 below are generally considered Class 3 flammable liquids and are subject to the provisions of the final rule when shipped in a HHFT. Class 3 combustible liquids (i.e. liquids with a flashpoint above 100 °F) are not subject to the provisions of the final rule. Some materials like crude oil, petroleum distillates, and other organic compounds such as amines display a wide range of flash points depending on their composition and as such may not be subject to the provisions in all cases. In other cases, a flammable liquid may be mixed with a non-hazardous material to the point that the flash point is within the range of a combustible liquid and would not be subject to the provisions of the final rule (e.g., dilute solutions of alcohol).

As shown in Table T1, approximately 68 percent of the flammable liquids transported by rail are comprised of crude oil, ethanol, and petrochemical or petroleum refinery products. These include: UN1987 Alcohols, n.o.s.[12]; UN1170 Ethanol; UN1219 Isopropanol; UN1230 Methanol; UN1267 Petroleum crude oil; UN1238 Petroleum distillates, n.o.s.; and UN3295 Hydrocarbons liquid n.o.s. Petrochemical or petroleum refinery products would include commonly shipped items like NA1993 Diesel fuel; NA1993 Combustible liquid, n.o.s.; UN1202 Diesel fuel; UN1202 Gas oil; UN1203 Gasoline; and UN1863 Fuel, aviation, turbine engine. The table below and Appendix A provide summary information for the industries that produce the most flammable liquid.

Further, ethanol and crude oil comprise approximately 65% of the flammable liquids transported by rail. Generally, ethanol is shipped as: UN1170 Ethanol; UN1987 Alcohols, n.o.s.; or UN3475 Ethanol and gasoline mixture or Ethanol and motor spirit mixture or Ethanol and petrol mixture, with more than 10% ethanol. Crude oil is shipped as: UN1267 Petroleum crude oil; UN1268 Petroleum distillates, n.o.s. or Petroleum products, n.o.s.; or UN3295 Hydrocarbons, liquid,

[12] Alcohols n.o.s. is a generic proper shipping name used to cover a variety of mixtures of alcohols such as ethanol mixed with methanol or isopropanol.

n.o.s. PHMSA expects few flammable liquids other than crude oil or ethanol to be shipped in a HHFT.[13]

Table I1. 2012 Class 3 Tank Car Originations by Commodity[14]

UN/NA Identification Number	Commodity	Total Tank Car Originations	Percent of Class 3 Tank Car Originations
NA1993	Diesel Fuel, Fuel Oil, Combustible Liquids N.O.S.	26,662	3.0%
UN1202	Diesel Fuel, Gas Oil	49,877	5.7%
UN1090	Acetone	4,083	0.5%
UN1093	Acrylonitrile, Stabilized	2,684	0.3%
UN1114	Benzene	7,376	0.8%
UN1120	Butanols	1,685	0.2%
UN1145	Cyclohexane	2,755	0.3%
UN1170	Ethanol	12,914	1.5%
UN1203	Gasoline	52,137	5.9%
UN1208	Hexanes	1,505	0.2%
UN1218	Isoprene, Stabilized	1,258	0.1%
UN1219	Isopropanol	2,288	0.3%
UN1230	Methanol	19,283	2.2%
UN1238	Petroleum Distillates, N.O.S	3,917	0.4%
UN1247	Methyl Methacrylate Monomer, Stabilized	4,768	0.5%
UN1265	Pentanes	1,541	0.2%
UN1267	Petroleum Crude Oil	266,495	30.3%
UN1268	Petroleum Distillates, N.O.S	8,202	0.9%
UN1280	Propylene Oxide	4,394	0.5%
UN1294	Toluene	3,956	0.4%
UN1301	Vinyl Acetate, Stabilized	5,053	0.6%
UN1307	Xylenes	10,466	1.2%
UN1863	Fuel,Aviation,Turbine Engine	16,782	1.9%
UN1987	Alcohols, N.O.S	293,451	33.3%
UN1993	Flammable Liquids, N.O.S	36,114	4.1%
UN2055	Styrene Monomer, Stabilized	13,355	1.5%
UN2348	Butyl Acrylates, Stabilized	3,389	0.4%
UN2370	1-Hexene	1,718	0.2%
UN2924	Flammable Liquids, Corrosive, N.O.S	1,242	0.1%
UN3065	Alcoholic Beverages	1,267	0.1%
UN3256	Elevated Temperature Liquid, Flammable, N.O.S	1,849	0.2%
UN3295	Hydrocarbons, Liquid, N.O.S	10,745	1.2%
UN3475	Ethanol And Gasoline Mixture	7,730	0.9%
Total		880,941	

A. Crude Oil

The U.S. is now the global leader in crude oil production growth. With a growing domestic supply, rail transportation, in particular, has emerged as a flexible alternative to transportation by

[13] The estimated number of cars of other flammable liquids that would be appended to HHFTs and hence must meet the new requirements is 354 tank cars. The costs presented in this analysis include retrofits to this small number of tank cars.

[14] Source: Annual Report of Hazardous Materials Transported by Rail by Association of American Railroads and Bureau of Explosives

pipeline or vessel. The volume of crude oil carried by rail increased 423 percent between 2011 and 2012.[15,16] In 2013, the number of rail carloads of crude oil surpassed 400,000.[17] The amount of crude oil and refined petroleum products moved by U.S. railroads continued to increase by 9 percent during the first 7 months of 2014, compared with the same period in 2013.[18] With the average rail tank car holding around 700 barrels of crude oil, about 759,000 barrels of crude oil per day were moved by rail during the first seven months of 2014, equal to 8 percent of U.S. oil production.[19]

Expansion in oil production has led to increasing volumes of product transported to refineries. Traditionally, pipelines and oceangoing tankers have delivered the vast majority of crude oil to U.S. refineries, accounting for approximately 93 percent of total receipts (in barrels) in 2012. Although other modes of transportation—rail, barge, and truck—have accounted for a relatively minor portion of crude oil shipments, volumes have been rising very rapidly. With a growing domestic supply, rail transportation, in particular, has emerged as a flexible alternative to transportation by pipeline or vessel. The transportation of large volumes of flammable liquids by rail under the current regulatory scheme poses a risk to life, property, and the environment. The volume of flammable liquids shipped by rail unit trains has been increasing rapidly since 2006, representing a growing risk. Figure 1 provides the average weekly U.S. rail carloads of crude oil and petroleum products from 2006 through 2014.

[15] See U.S. Rail Transportation of Crude Oil: Background and Issues for Congress; http://fas.org/sgp/crs/misc/R43390.pdf

[16] See Table 9 of EIA refinery report http://www.eia.gov/petroleum/refinerycapacity/ See also "Refinery receipts of crude oil by rail, truck, and barge continue to increase" http://www.eia.gov/todayinenergy/detail.cfm?id=12131

[17] http://www.stb.dot.gov/stb/industry/econ_waybill.html

[18] http://www.eia.gov/todayinenergy/detail.cfm?id=17751

[19] http://www.eia.gov/todayinenergy/detail.cfm?id=17751

Figure 1: Average Weekly U.S. Rail Carloads of Crude Oil and Petroleum Products

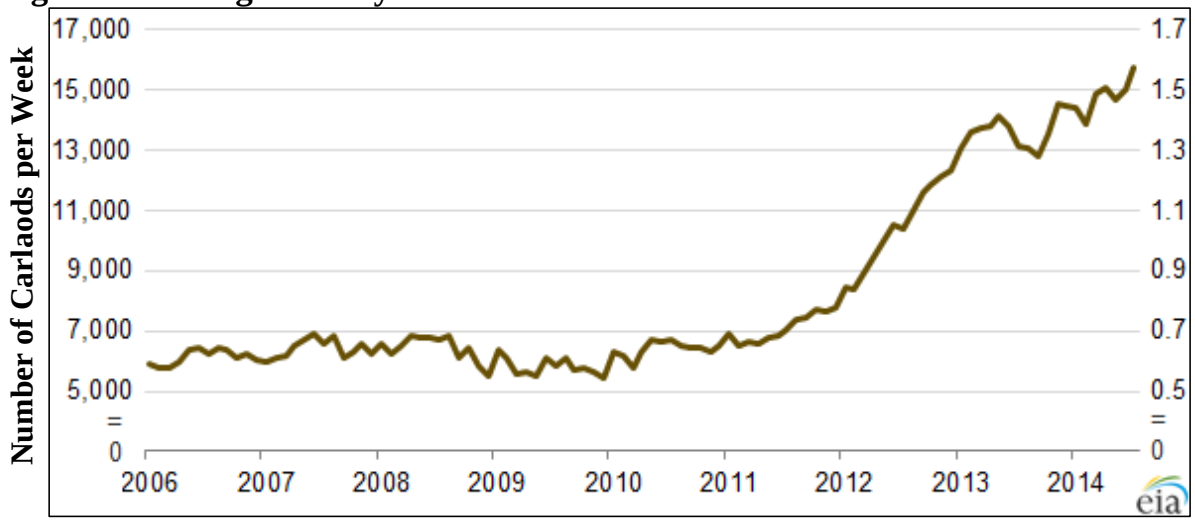
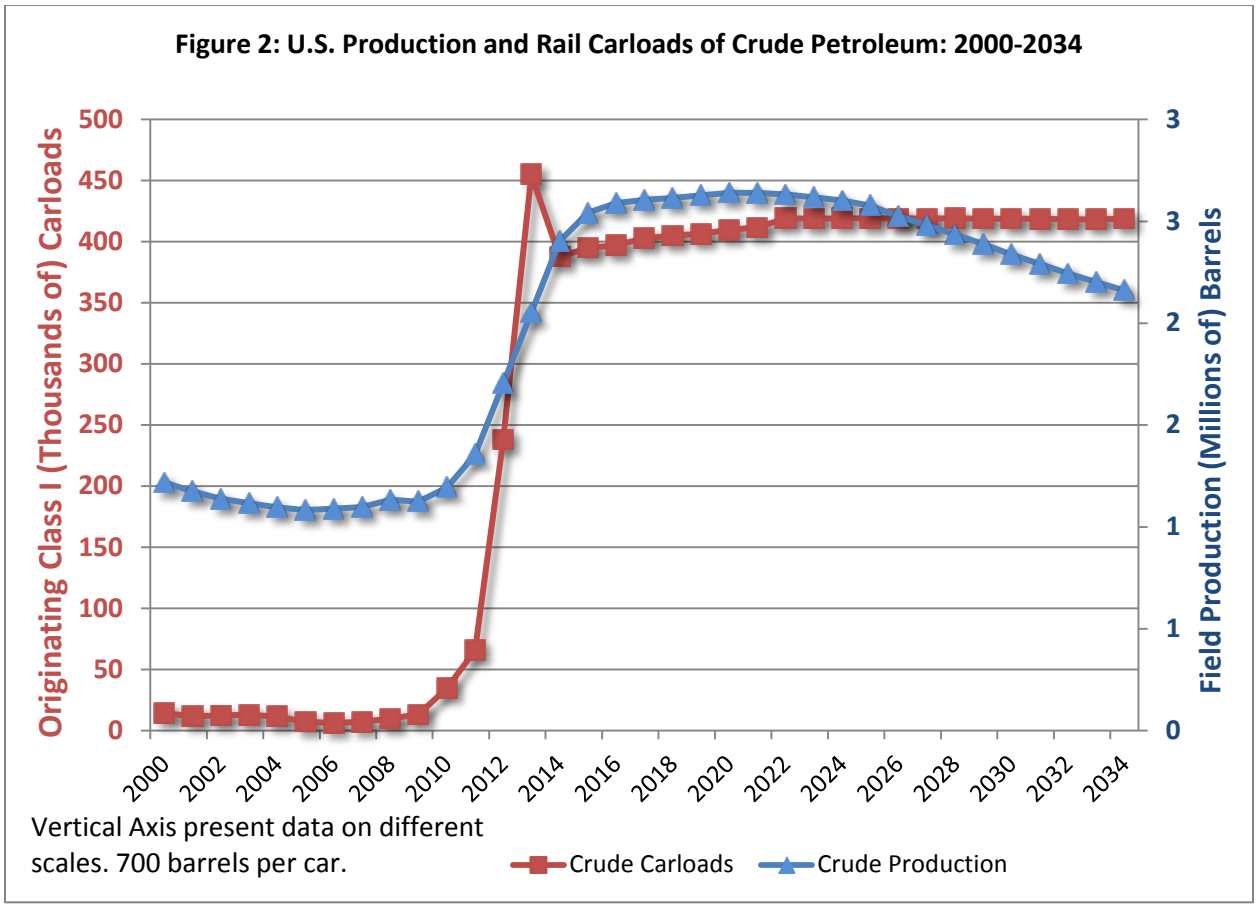


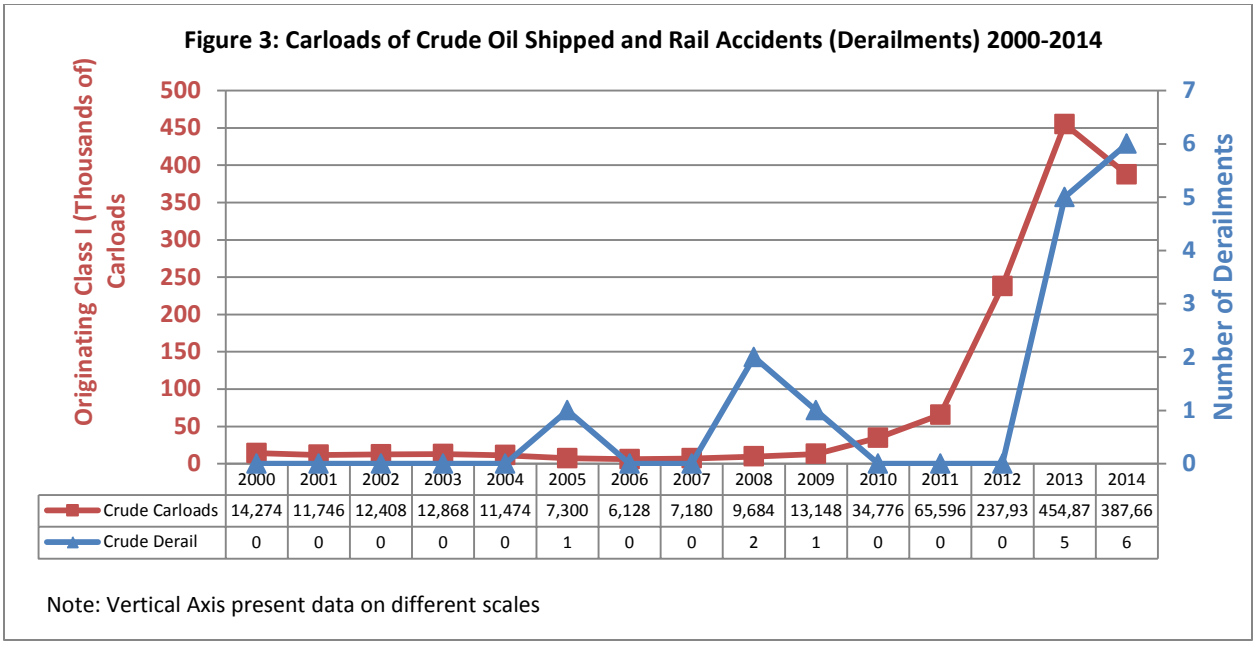
Figure 2 shows the recent strong growth in crude oil production in the U.S., as well as growth in the number of rail carloads shipped. Figure 2 also shows forecasted domestic crude oil production from the Energy Information Administration (EIA) and PHMSA's projected strong demand for the rail shipment of crude oil.



Sources and Notes: Crude Carloads for 2000-2013 obtained from the Surface Transportation Board waybill sample. Forecasts of overall domestic crude oil production and carload figures from 2014-2034 are taken from the report prepared by the Brattle Group on behalf of RSI [Table 14]. Crude production figures were derived from the EIA domestic crude production from 2014 Annual Energy Outlook.

Rail accidents have risen along with the increase in crude oil production and rail shipments of crude oil. Figure 3 shows this rise.[20]

[20] Source: STB Waybill Sample and PHMSA Incident Report Database



Sources and notes: Originating Class I Carloads for 2000-2013 obtained from the Surface Transportation Board waybill sample. 2014 originating carloads are estimated based on EIA production forecast in millions of barrels per year then converted to carloads per year. Incident counts are from the PHMSA and FRA Incident Report Databases.

Based on these train accidents, the projected continued growth of domestic crude oil production, and the growing number of train accidents involving crude oil, PHMSA concludes that the potential for a train accident involving crude oil has increased, which has raised the likelihood of a catastrophic train accident that would cause substantial damage to life, property, and the environment.

B. Ethanol

In the last ten years, the production of ethanol has increased dramatically due to the demand for ethanol-blend fuels. U.S. production of ethanol was 14.3 billion gallons in 2014.[21] Denatured ethanol (approximately 95 percent ethanol is largely shipped from production facilities by rail and is now the largest volume hazardous material shipped by rail. Unit trains commonly ship

Source: U.S. Energy Information Administration : "January 2015 Monthly Energy Review"

U.S. Energy Information Administration
"January 2015 Monthly Energy Review" Annual Data:
www.eia.gov/totalenergy/data/browser/xls.cfm?tbl=T10.03&freq=m

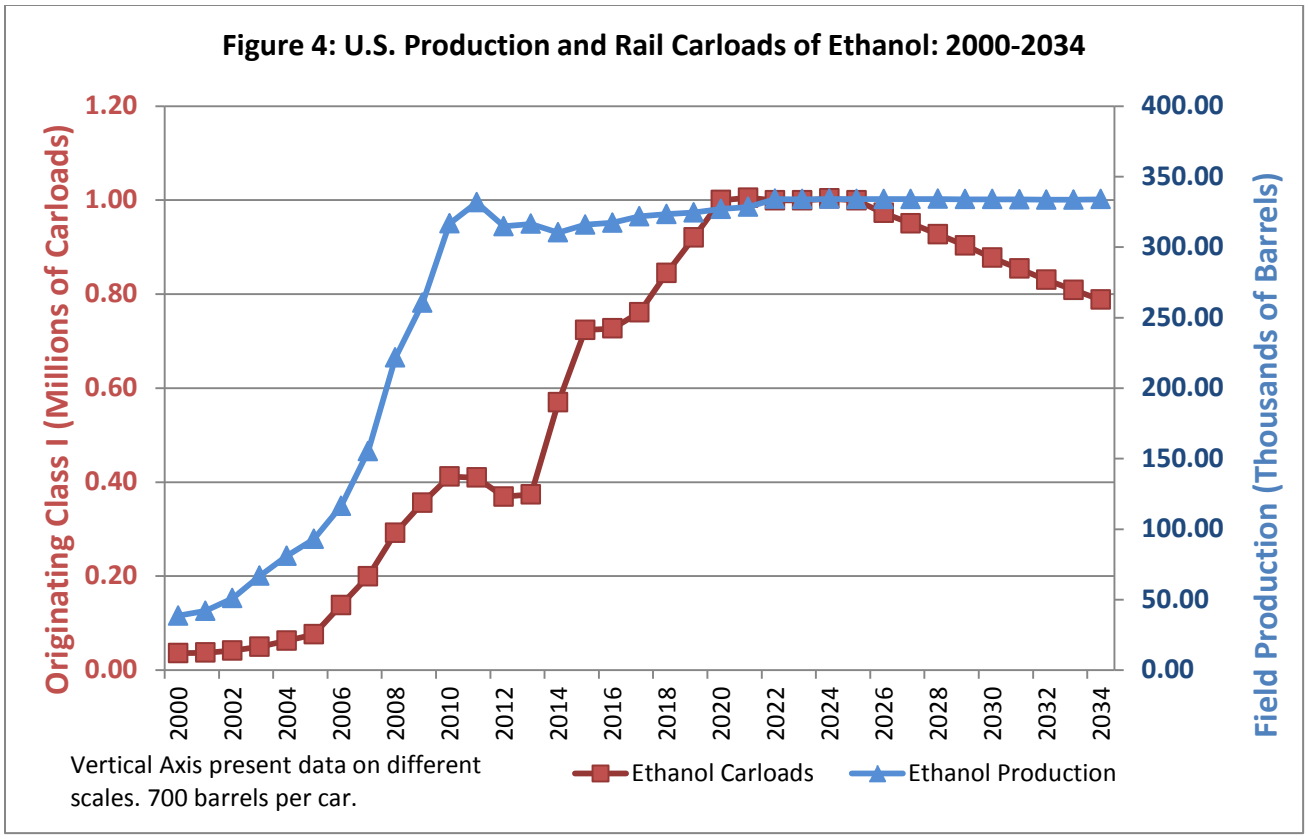
large volumes of ethanol in up to 3.2 million gallons. Barges can transport up to 2.5 million gallons.[22]

Ethanol is a flammable colorless liquid; a polar solvent that is completely miscible in water. It is heavier than air, and has a wider flammable range than gasoline, with a Lower Explosive Limit (LEL) to an Upper Explosive Limit (UEL)[23] range of 3.3 percent to 19 percent. The flash point for pure ethanol is 55°F, and for fuel ethanol it is much lower (-5°F). Ethanol is still considered a flammable liquid in solutions as dilute as 20 percent, with a flash point of 97°F. Fuel ethanol is shipped with a flammable liquids placard and North American 1987 designation.[24] As shown in Figure 4, EIA projects strong demand for ethanol in the future.

[22] Source: "Large Volume of Ethanol Spills – Environmental Impacts and Response Options" prepared for MassDEP, Commonwealth of Massachusetts Department of Environmental Protection by Shaw in July 2011.

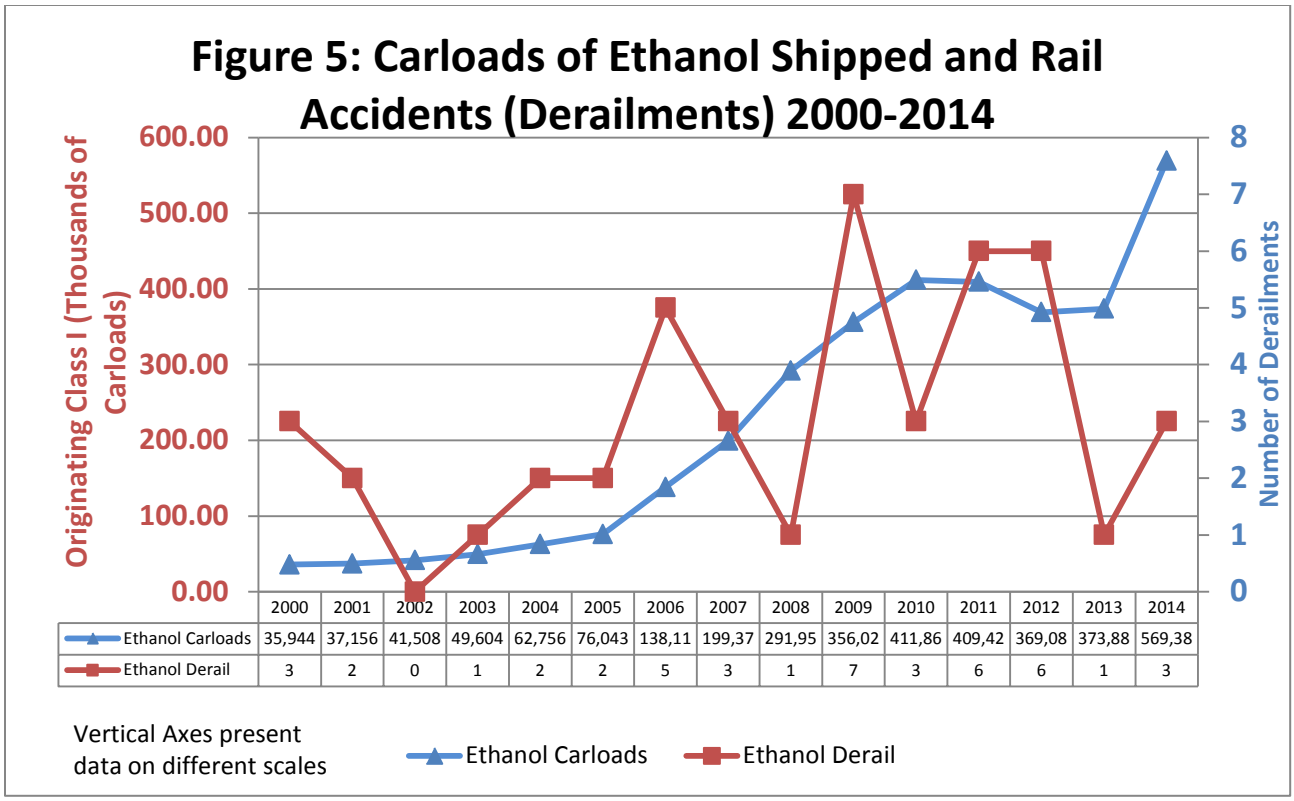
[23] Lower explosive limit refers to the minimum concentration of a combustible gas or vapor necessary to support combustion in air. Upper flammability limit refers to the maximum concentration of gas or vapor necessary to support combustion in air. Beyond these limits the mixture is either too lean or too rich to burn.

[24] Source: Large Volume Ethanol Spills – Environmental Impacts and Response Options, MassDEP, http://www.mass.gov/eopss/docs/dfs/emergencyresponse/special-ops/ethanol-spill-impacts-and-response-7-11.pdf



Sources and notes: Originating Class I Carloads for 2000-2013 were obtained from the Surface Transportation Board Waybill sample. Forecasts of overall domestic ethanol production are obtained from the 2014 EIA forecast. The carload forecast from 2014-2034 is based on production using Excel's Forecast function using an estimated linear trend of historic ethanol carloads based on historic production.

According to a June 2012 white paper by the AAR, U.S. ethanol production increased considerably during the last 10 years and has generated similar growth in the transportation of ethanol by rail. Between 2001 and 2012, the number of rail carloads of ethanol increased by 650 percent. Similarly, the number of rail carloads of crude oil has also exponentially increased. Unfortunately, this growth in rail traffic has been accompanied by an increase in the number of rail accidents involving ethanol and crude oil. Figure 5 plots the total number of rail accidents involving ethanol during the last 13 years compared to the total carloads of ethanol. The left axis shows the total number of rail derailments and the right axis shows total carloads shipped.



Sources and notes: Originating Class I Carloads for 2000-2013 obtained from the Surface Transportation Board waybill sample. 2014 originating carloads are estimated based on EIA production forecast in millions of barrels per year converted to carloads per year. Incident counts are from the PHMSA and FRA Incident Report Databases.

III. Determination of Need

The principal anticipated benefit associated with the final rule is a reduction in the risk of HHFT accidents and mitigation of the consequences when such accidents do occur. The following discussion provides an overview of PHMSA's and FRA's concerns by first discussing rail accidents involving large volumes of flammable liquids, which could increase the risk of potential catastrophic train accidents in the future, and concludes with an appraisal of the regulatory options PHMSA is considering to limit future releases.

A. Market Failures

A market failure at issue is that the shippers and rail companies are not insured against the full liability of the consequences of incidents involving hazardous materials. Even with adequate insurance it is unclear whether full compensation for the consequences of events that may result in severe injury or death is possible, resulting in external costs that go unrecompensed regardless of the insurance carried by the railroad. Incidents involving severe negligence on the part of the carrier may therefore result in harm that goes uncompensated. Finally, to process a claim to insurance compensation, those harmed must demonstrate real harm and value lost. In the case of damage to the environment the actual monetary value of lost or damaged assets is difficult to

determine. As a result, these events impose externalities. In the initial RIA, we indicated that among Class I railroads a self-insured retention of $25 million is common, though it can be as much as $50 million, especially when toxic if inhaled (TIH) material is involved. Smaller regional and short line carriers, i.e., Class II and Class III railroads, on the other hand, typically maintain retention levels well below $25 million as they usually have a more conservative view of risk and usually do not have the cash flow to support substantial self-insurance levels.[25] Further, the maximum coverage available in the commercial rail insurance market appears to be $1 billion per carrier, per incident.[26] While this level of insurance is sufficient for the vast majority of accidents, it is inadequate to cover some higher-consequence events. One example of this issue is the incident that occurred at Lac-Mégantic, Quebec, in July 2013. The rail carrier responsible for the incident was covered for a maximum of $25 million in insurance liability and had to declare bankruptcy because that coverage and the company's remaining capital combined were insufficient to pay for more than a fraction of the harm that was caused economic losses preliminarily estimated at more than $1 billion. This is one example where rail carriers and shippers had insufficient coverage to bear the entire cost of "making whole" those affected when an incident involving crude and ethanol shipment by rail occurred. Further, some damages are unlikely to lead to liability, including any damages to the American public's non-use values of an area where a release occurs, as well as small amounts of per capita damages that can be large overall if they affect a large number of people. For instance, if a release causes an evacuation, the affected groups may not suffer enough harm to overcome the fixed costs of litigating that harm, and coordination among the people affected may be difficult.

On October 9, 2014, American International Group, Inc. (AIG) expanded the excess casualty liability limits for Class I railroads to $1 billion per accident. This was done in response to the demand for transport of crude oil by rail.

According to Jeremy Johnson, president and chief executive officer, Lexington Insurance Company, who will provide the excess coverage, "Rail companies need additional coverage to help protect their balance sheets." [27] Further, Mr. Johnson indicated, "this billion-dollar coverage will help Class I railroads address expanding risks while continuing to serve the growing needs of transportation customers in North America."

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[25] http://www.dot.gov/office-policy/transportation-hazardous-materials-insurance-security-and-safety-costs (section 3.4 Rail Liability and Insurance Controversy).

[26] http://www.dot.gov/office-policy/transportation-hazardous-materials-insurance-security-and-safety-costs (section 3.4 Rail Liability and Insurance Controversy).

[27] http://www.railwayage.com/index.php/freight/class-i/aig-provides-expanded-1-billion-casualty-liability-limits-for-north-american-rail-companies.html?channel=Array

Another issue is that shippers, though responsible for buying or leasing the tank cars in which these products are shipped, and loading the material into the tank cars, but do not generally bear any liability for an incident once a rail carrier has accepted shipment, and rail carriers cannot refuse shipments because of their common carrier obligation.[28] In addition, the rates that rail carriers can charge to move these commodities are generally negotiated between the shipper and the carrier on a contract basis and regulated by the Surface Transportation Board. Shippers, by virtue of not bearing liability, may lack an appropriate full incentive to ensure that the tanks cars are adequate to appropriately address the level of risk.

B. Rail Accidents

As is required of all accidents involving a release of hazardous materials in transportation in the United States,[29] derailments are reported to PHMSA and are recorded in the hazardous materials incident report database. As described in Appendix B, train accidents involving a release of flammable liquids and subsequent fire have occurred with increasing frequency, including:

1) *April 2014*: A train carrying crude oil derailed seventeen cars two of which released a total of approximately 30,000 gallons of crude oil in the James River. Approximately 350 residents were evacuated for approximately 3.5 hours.
2) *December 2013:* A train carrying crude oil derailed and ignited near Casselton, ND, prompting authorities to issue a voluntary evacuation of the city and surrounding area.
3) *November 2013:* A train carrying crude oil to the Gulf Coast from North Dakota derailed in Aliceville, Alabama, spilling crude oil in a nearby wetland and igniting into flames.
4) *July 2013:* An unattended train carrying crude oil derailed in Lac-Mégantic, Quebec, Canada that caused the 47 deaths, extensive damage to the town center, and the evacuation of approximately 2,000 persons from the surrounding area.

The Lac-Mégantic accident resulted in economic losses preliminarily estimated at more than $1 billion.[30] On August 2, 2013, FRA issued Emergency Order No. 28, which identified the following:

1) Crude oil is problematic when released because of its flammability, and the risk is compounded because it is commonly shipped in large volume;

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[28] In an effort to encourage the use of different tank cars, some rail carriers impose a surcharge on customers who offer crude oil in DOT111 tank cars.

[29] See 49 C.F.R 171.15, 171.16.

[30] Please see Appendix C for a description of how these costs were estimated.

2) Similar dangers exist with other hazardous materials such as ethanol, which was transported via rail more than any other hazardous material in 2012;
3) Although the Lac-Mégantic accident occurred in Canada, the freight railroad operating environment in Canada is similar to that in the United States.

On January 23, 2014, in response to its investigation of the Lac-Mégantic accident, the NTSB released a report stating that at least 60 of the 63 derailed DOT-111 tank cars released a total of about 1.6 million gallons of crude oil. According to the NTSB, "The Lac-Mégantic accident shows that railroad accidents involving crude oil have a potential for disastrous consequences and environmental contamination equal to that of the worst on-shore pipeline accidents."

FRA has proposed a separate rulemaking to address train attendance issues, but aspects of the Lac-Mégantic accident are relevant to this rulemaking. This accident occurred in a relatively small town with low rail traffic volumes, but occurred in a congested area with a place of congregation near the tracks.[31]While imperfect, PHMSA uses population density is a proxy for the presence of places of congregation. PHMSA and FRA are taking this regulatory step to mitigate damage from accidents involving HHFTs, including catastrophic accidents that could occur that result in damages even greater than a Lac-Mégantic accident, as well as lower-consequence events that do not involve outsized environmental and property damages or multiple fatalities.

Appendix B highlights this risk by summarizing the impacts of recent accidents involving HHFTs of crude oil and ethanol. While other accidents involving crude oil and ethanol have not released as much product and have not had as significant consequences as those shown in Appendix B, these accidents indicate the potential harm from future releases.

C. Precursors and Forewarnings

To consider the likelihood of future catastrophic accidents in the absence of regulatory changes, PHMSA analyzed modal transportation data, historical accident data, and the market forecasts for crude oil and ethanol. In addition, PHMSA and FRA have many initiatives underway to address freight rail safety including risk reduction programs, track safety standards, positive train control, equipment securement, a retrospective review of the requirements for the carriage of hazardous materials by rail (Part 174) and oil spill response plans. Many of these actions address different parts of rail safety including operational issues that are outside of PHMSA's purview.

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[31] According to the Canada 2011 Census, Lac-Mégantic had a population of 5,932. The town occupies a land area of 21.77 square kilometers (8.41 sq mi) and a population density of 272.5 inhabitants per square kilometer (706 /sq mi). Source; http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=2430030&Geo2=PR&Code2=24&Data=Count&SearchType=Begins&SearchPR=01&B1=All

However, we do not expect these measures to reduce the derailment rate per carload for crude and ethanol trains in the future.

In general, PHMSA and FRA found that several factors give rise to higher expected damages and probability of a catastrophic event when comparing high volume flammable liquid shipments to the historic record, which features comparatively small volumes of flammable liquids shipped by rail. First, the volumes of crude oil and ethanol carried by rail are relatively large when compared to rail shipments of other flammable liquids.[32] In particular, the volume of crude oil shipped by rail has been increasing rapidly during the past several years. Finally, crude oil and ethanol are increasingly shipped in HHFTs, compounding the risk of greater damages when an accident does occur, while other flammable liquids are generally shipped in smaller volumes with other, non-flammable materials.

The North Dakota Industrial Commission adopted new conditioning standards that would require crude oil produced there to have a Vapor Pressure of Crude Oil not greater than 13.7 psi or 1 percent less than the vapor pressure of stabilized crude oil as defined in the latest version of ANSI/API RP3000 whichever is lower. It is our understanding that the level of Pre-treatment described in this order will not have a drastic effect as most of the crude in North Dakota tests below 13.7 already. We are not able make any definitive statements on the impact on the baseline likelihood of future fires or explosions from derailments involving North Dakota crude.

Due to these recent changes, PHMSA and FRA have concluded that the historical train accident record alone does not reflect the probability of a catastrophic event in the future.

D. Appraisal of Final Rule Provisions

In the absence of PHMSA regulatory action (the "no action" alternative), current requirements would remain in place, and no new provisions would be added. In this case, the safety and environmental risks related to HHFTs would not be addressed. A lack of action by PHMSA would ignore the significant consequences experienced in serious train accidents. In order to mitigate the societal costs of future accidents, PHMSA has worked closely with FRA to take regulatory action that will prevent and mitigate future train accidents. The final rule provisions are described in the sections that follow.

[32] A unit train of flammable liquids increases the number of hazmat cars in a single train and potential number of hazmat cars that could potentially derail in a single event. Previous studies have found that a greater residual train length is expected to result in more cars derailed given all else being equal (e.g., Saccomanno and El-Hage, 1989,1991; Anderson, 2005). If all of the cars in a train contain hazmat, more hazmat would release. Intuitively this would result in a higher likelihood of a catastrophic event.

IV. Final Rule Provisions

The HMR are designed to achieve three goals: (1) to ensure that hazardous materials are packaged and handled safely and securely during transportation; (2) to provide effective communication to transportation workers and emergency responders of the hazards of the materials being transported; and (3) to reduce the likelihood that a train carrying high volumes of flammable liquids will derail, and also minimize the consequences of an incident should one occur. The hazardous material regulatory system is a risk management system that is prevention-oriented and focused on identifying a safety or security hazard, thus reducing the probability and quantity of a hazardous material release.

Under the HMR, hazardous materials are categorized by analysis and experience into hazard classes and Packing Groups based upon the risks that they present during transportation. The HMR specify appropriate packaging and handling requirements for hazardous materials based on such classification, and require an offeror to communicate the material's hazards through the use of shipping papers, package marking and labeling, and vehicle placarding. The HMR also require offerors to provide emergency response information applicable to the specific hazard or hazards of the material being transported. Further, the HMR mandate training for persons who prepare hazardous materials for shipment or who transport hazardous materials in commerce and require the development and implementation of plans to address security risks related to the transportation of certain types and quantities of hazardous materials in commerce, including additional planning requirements for transportation by rail (e.g., the routing of the material).

PHMSA is establishing regulatory requirements for flammable liquids transported in HHFTs. The final rule defines a HHFT as a train comprised of 20 or more tank cars in a block or 35 tank cars across the train consist loaded with flammable liquids and ensures that the rail requirements are more closely aligned with the risks posed by the operation of these trains. Our intent is to address the risks posed by large blocks or unit train shipments of flammable liquids. Generally, ethanol and crude oil are the flammable liquids most frequently transported in high volume shipments, such as HHFTs. By focusing on this growing risk, we will mitigate the vulnerabilities and consequences associated with accidents involving large volumes of flammable liquids, as evidenced in the rail accidents of recent years.

In the section that follows we provide an overview of the following provisions, as adopted in the final rule:

1) Tank Car Specifications
2) Advanced Brake Signal Propagation Systems
3) Speed Restrictions
4) Routing Requirements
5) Classification of Unrefined Petroleum-Based Products

A. Routing Requirements

1. Regulatory Change

In the final rule, PHMSA is requiring rail carriers to perform an analysis that considers 27 safety and security factors for routing HHFTs. The carrier must select a route based on findings of the route analysis. These planning requirements are prescribed in 49 CFR § 172.820 for trains carrying security-sensitive hazardous materials and would be expanded to apply to HHFTs. This replaces the proposed requirements to notify State Emergency Response Commissions (SERCs) or other appropriate state delegated entity about the operation of these trains through their States.

Table P1: Performance Factors Considered in This Safety and Security Risk Analysis		
Volume of hazardous material transported	Rail traffic density	Trip length for route
Presence and characteristics of railroad facilities	Track type, class, and maintenance schedule	Track grade and curvature
Presence or absence of signals and train control systems along the route ("dark" versus signaled territory)	Presence or absence of wayside hazard detectors	Number and types of grade crossings
Single versus double track territory	Frequency and location of track turnouts	Proximity to iconic targets
Environmentally sensitive or significant areas	Population density along the route	Venues along the route (stations, events, places of congregation)
Emergency response capability along the route	Areas of high consequence along the route, including high consequence targets	Presence of passenger traffic along route (shared track)
Speed of train operations	Proximity to en route storage or repair facilities	Known threats, including any threat scenarios provided by the DHS or the DOT for carrier use in the development of the route assessment
Measures in place to address apparent safety and security risks	Availability of practicable alternative routes	Past accidents
Overall times in transit	Training and skill level of crews	Impact on rail network traffic and congestion

2. Overview

Careful consideration of a rail route with regard to a variety of risk factors can mitigate risk of an accident. For some time, there has been considerable public and Congressional interest in the safe and secure rail routing of security-sensitive hazardous materials (such as chlorine and anhydrous ammonia). The Implementing Recommendations of the 9/11 Commission Act of 2007 directed the Secretary, in consultation with the Secretary of Homeland Security, to publish a rule governing the rail routing of security-sensitive hazardous materials. On December 21, 2006, PHMSA, in coordination with FRA and the Transportation Security Administration (TSA) of the U.S. Department of Homeland Security (DHS), published an NPRM under Docket HM-

232E (71 FR 76834), which proposed to revise the current requirements in the HMR applicable to the safe and secure transportation of hazardous materials by rail. Specifically, we proposed to require rail carriers to compile annual data on specified shipments of hazardous materials, use the data to analyze safety and security risks along rail routes where those materials are transported, assess alternative routing options, and make routing decisions based on those assessments.

In that NPRM, we solicited comments on whether the proposed requirements should also apply to flammable gases, flammable liquids, or other materials that could be weaponized, as well as hazardous materials that could cause serious environmental damage if released into rivers or lakes. Commenters who addressed this issue indicated that rail shipments of Division 1.1, 1.2, and 1.3 explosives; Poisonous by Inhalation (PIH) materials; and highway-route controlled quantities of radioactive materials pose significant rail safety and security risks warranting the enhanced security measures proposed in the NPRM and adopted in a November 26, 2008 final rule (73 FR 20752). Commenters generally did not support enhanced security measures for a broader list of materials than were proposed in the NPRM.

The City of Las Vegas, Nevada, did support expanding the list of materials for which enhanced security measures are required to include flammable liquids; flammable gases; certain oxidizers; certain organic peroxides; and 5,000 pounds or greater of pyrophoric materials. While DOT and DHS agreed that these materials pose certain safety and security risks in rail transportation, the risks were not as great as those posed by the explosive, PIH, and radioactive materials specified in the NPRM, and PHMSA was not persuaded that they warranted the additional safety and security measures. PHMSA did note, however, that DOT, in consultation with DHS, would continue to evaluate the transportation safety and security risks posed by all types of hazardous materials and the effectiveness of our regulations in addressing those risks and would consider revising specific requirements as necessary.

The final rule implemented regulations requiring rail carriers to compile annual data on certain shipments of explosive, toxic by inhalation, and radioactive materials; use the data to analyze safety and security risks along rail routes where those materials are transported; assess alternative routing options; and make routing decisions based on those assessments. In accordance with § 172.820(e), the carrier must select the route posing the least overall safety and security risk. The carrier must retain in writing all route review and selection decision documentation. Additionally, the rail carrier must identify a point of contact on routing issues involving the movement of covered materials and provide the contact information to the appropriate State, local, and tribal personnel.

Rail carriers must assess available routes using, at a minimum, the 27 factors listed in Appendix D to Part 172 of the HMR to determine the safest, most secure routes for security-sensitive hazardous materials.

The HMR require carriers to make conscientious efforts to develop logical and defendable systems using these factors. Risk can be minimized practically in two ways: one is to run shipments over the highest-quality track, i.e. track that poses the lowest risk for derailment, collision, or other train accident. The other way risk can be reduced is to reduce exposure to train accidents. Rerouting can address either or both of these risk factors, but in some cases, one factor

must be traded off against another. In some cases, rail carriers might choose a route that eliminates exposure in areas with high population densities but poses a risk for more frequent events in areas with low population densities. In other cases, the risk of derailment may be so low along a section of track that, even though it runs through a densely populated area, it poses the lowest total risk when severity and likelihood are considered.

FRA enforces the routing requirements in the HMR and is authorized, after consulting with PHMSA, TSA, and the STB, to require a railroad to use an alternative route other than the route selected by the railroad if it is determined that the railroad's route selection documentation and underlying analysis are deficient and fail to establish that the route chosen poses the least overall safety and security risk based on the information available (49 CFR 209.501).

On January 23, 2014, in response to its investigation of the Lac-Mégantic accident, the NTSB issued three recommendations to PHMSA and FRA. Recommendation R-14-4, in particular, requested PHMSA work with FRA to expand hazardous materials route planning and selection requirements for railroads to include *key trains* transporting flammable liquids as defined by the AAR Circular No. OT-55-N and, where technically feasible, require rerouting to avoid transportation of such hazardous materials through populated and other sensitive areas.

B. Tank Car Specifications

1. Regulatory Change

In the final rule, PHMSA is adopting enhanced standards for both new and existing tank cars. PHMSA will revise the HMR to require new tank cars constructed after October 1, 2015 (that are used to transport flammable liquids as part of an HHFT) to meet enhanced design criteria (DOT-117), including specific design requirements or performance criteria. In addition, the HMR will require existing tank cars that are used to transport flammable liquids as part of an HHFT to be retrofitted to meet an enhanced CPC-1232 standard, based on Packing Group and tank car based retrofit schedule.

2. Overview

Proper classification is essential when selecting an appropriate packaging for a hazardous material. The HMR is designed to provide a list of packagings for each material that can appropriately contain the material and its hazards. Based on the shipping name of a hazardous material, the HMT provides the list of packagings authorized for use by the HMR. For each proper shipping name, bulk packaging requirements are provided in Column 8C of the § 172.101 HMT.

The offeror must select a packaging that is suitable for the properties of the material and based on the packaging authorizations provided by the HMR. With regard to package selection, the HMR require in § 173.24(b) that each package used for the transportation of hazardous materials be "designed, constructed, maintained, filled, its contents so limited, and closed, so that under conditions normally incident to transportation…there will be no identifiable (without the use of

instruments) release of hazardous materials to the environment [and]… the effectiveness of the package will not be substantially reduced." Under this requirement, offerors must consider how the properties of the material (which can vary depending on temperature and pressure) will affect the packaging.

For most flammable liquids, the authorized packaging requirements for a PG I material are provided in § 173.243 and for PGs II and III in § 173.242. Table P2 has been provided as a general guide for the packaging options for rail transport provided by the HMR for flammable and combustible liquids.

Table P2: Tank Car Options[33]

Flammable Liquid, PG I	Flammable Liquid, PG II and III	Combustible Liquid
DOT 103	DOT 103	DOT 103
DOT 104	DOT 104	DOT 104
DOT 105	DOT 105	DOT 105
DOT 109	DOT 109	DOT 109
DOT-111	DOT-111	DOT-111
DOT 112	DOT 112	DOT 112
DOT 114	DOT 114	DOT 114
DOT 115	DOT 115	DOT 115
DOT 120	DOT 120	DOT 120
	AAR 206W	AAR 206W
		AAR 203W
		AAR 211W

Note 1 Sections 173.241, 173.242, and 173.243 authorize the use of the above tank cars.
Note 2. DOT 103, 104,105, 109, 112, 114, and 120 tank cars are pressure tank cars (HMR; Part 179, Subpart C).
Note 3. DOT-111 and 115 tank cars are non-pressure tank cars (HMR; Part 179, Subpart D).
Note 4. AAR 203W, AAR 206W, and AAR 211W tank cars are non-DOT specification tank cars that meet AAR standards. These tank cars are authorized under § 173.241 of the HMR (see Special Provision B1, as applicable).
Note 5. DOT-114 and DOT 120 pressure cars are permitted to have bottom outlets and, generally, would be compatible with the DOT-111.

The packaging authorizations are currently indicated in the HMT and part 173, subpart F. DOT-111 tank cars are authorized for low, medium and high-hazard liquids and solids (equivalent to Packing Groups III, II, and I, respectively). Packing Groups are designed to assign a degree of danger presented within a particular hazard class. Packing Group I poses the highest danger ("great danger") and Packing Group III the lowest ("minor danger").[34] In addition, the general

[33] Additional information on tank car specifications is available at the following URL: http://www.bnsfhazmat.com/refdocs/1326686674.pdf

[34] Packing Groups, in addition in indicating risk of the material, can trigger levels of varying requirements. For example Packing Groups can indicate differing levels of testing requirements for a non-bulk packaging, or the need for additional operational requirements such as security planning requirements.

packaging requirements prescribed in § 173.24 provide additional consideration for selecting the most appropriate packaging from the list of authorized packaging identified in column (8) of the HMT.

The DOT-111 tank car is one of several cars currently authorized by the HMR for the rail transportation of many hazardous materials, including ethanol, crude oil and other flammable liquids. For a summary of the design requirements of the DOT-111 tank car, see Table P2 in the tank car portion of the discussion of comments. Recent growth in demand for rail carriage of crude oil[35] and ethanol[36] has increased the risk of train accidents involving those materials. Major train accidents often result in the release of hazardous materials. These events pose a significant danger to the public and the environment. FRA closely monitors train accidents involving hazardous materials and documents the damage sustained by all cars involved in the accident.

In published findings from the June 19, 2009, incident in Cherry Valley, Illinois, the NTSB indicated that the DOT-111 tank car can almost always be expected to breach in the event of a train accident resulting in car-to-car impacts or pileups.[37] In addition, PHMSA received numerous petitions encouraging rulemaking and both FRA and PHMSA received letters from members of Congress in both parties urging prompt, responsive actions from the Department. The Association of American Railroads (AAR) created the T87.6 Task Force to consider several enhancements to the DOT-111 tank car design and rail carrier operations to enhance rail transportation safety. Simultaneously, FRA conducted research on long-standing safety concerns regarding the survivability of the DOT-111 tank cars designed to current HMR standards and used for the transportation of ethanol and crude oil, focusing on issues such as puncture resistance and top fittings protection. The research indicated that special consideration is necessary for the transportation of ethanol and crude oil in DOT-111 tank cars, especially in HHFTs.

In addition, PHMSA and FRA reviewed the regulatory history pertaining to flammable liquids transported in tank cars. Prior to 1990, the distinction between material properties that resulted

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[35] In 2013 there were approximately 400,000 originations of tank car loads of crude oil. In 2012, there were nearly 234,000 originations. In 2011 there were nearly 66,000 originations. In 2008 there were just 9,500 originations. Association of American Railroads, *Moving Crude Petroleum by Rail*, http://DOT-111.info/wp-content/uploads/2014/01/Crude-oil-by-rail.pdf (December 2013).

[36] In 2011 there were nearly 341,000 originations of tank car loads of ethanol, up from 325,000 in 2010. In 2000 there were just 40,000 originations. Association of American Railroads, *Railroads and Ethanol*, https://www.aar.org/keyissues/Documents/Background-Papers/Railroads%20and%20Ethanol.pdf (April 2013).

[37] National Transportation Safety Board, *Railroad Accident Report - Derailment of CN Freight Train U70691-18 With Subsequent Hazardous Materials Release and Fire*, http://www.ntsb.gov/doclib/reports/2012/RAR1201.pdf (February 2012)

in different packaging, for flammable liquids in particular, was described in far more detail in § 173.119. Section 173.119 indicated that the packaging requirements for flammable liquids are based on a combination of flash point, boiling point, and vapor pressure.

In 2011, the AAR issued Casualty Prevention Circular (CPC) 1232, which outlines industry requirements for certain DOT-111 tanks ordered after October 1, 2011, intended for use in ethanol and crude oil service (construction approved by FRA on January 25, 2011).[38] The CPC-1232 requirements are intended to improve the crashworthiness of the tank cars and include a thicker shell, head protection, top fittings protection, and pressure relief valves with a greater flow capacity.

C. Advanced Braking Systems

1. Regulatory Change

The final rule requires all HHFTs be equipped with advanced braking systems. All HHFTs would be operated with either a two-way end of train device (EOT), or distributed power (DP). In addition, after December 31, 2020, a train 1) consisting of 70 tank cars or more of flammable liquids, and 2) operating at a speed exceeding 30 mph must be operated in Electronically Controlled Pneumatic (ECP) braking mode.

2. Overview

The effective use of braking on a train set can result in accident avoidance and potentially lessen the consequences of an accident by diminishing the number of derailed tank cars. Currently, the FRA promulgates brake system standards for freight and other non-passenger trains and equipment in Title 49 CFR Part 232. Specifically, this part provides requirements for 1) General Braking, 2) Inspection and Testing, 3) Periodic Maintenance, 4) End-of-Train Devices, and 5) Introduction of New Technologies and Electronically Controlled Pneumatic Braking.

Australian Experience

In contrast to the experience in the United States, railroads in countries such as Australia have been much more accepting of this new technology.[39] Australia has been using ECP brakes on a

[38] See the Background section of the August 1 NPRM for information regarding a detailed description of PHMSA and FRA actions to allow construction under CPC-1232.

[39] South Africa is another strong adopter of ECP brakes, with about 7,000 railcars equipped with ECP brake technology. It is similar to Australia in that ECP brakes are being used in heavy haul coal service where the trains operate in a continuous loop and the railroads own their own railcars for this service.

portion of its fleet for over a decade.[40] Australia operates over 28,000 cars in ECP brake mode. The fleet Australia has been operating in ECP brake mode has many similarities to the United States' HHFUT fleet. Both fleets operate in heavy haul service, and both fleets transport commodities that are a substantial source of revenue for the railroad. Many stakeholders have noted that the increase in crude oil is equivalent to the mining boom in Australia. Indeed, although coal trains have traditionally been the bread and butter of railroads services, crude oil recently has become relatively more important.[41]

The 2014 Sismey and Day report identifies several bulk commodity services in Australia that have used ECP brakes since 2005 and a unit train mineral service that retrofit its trains with ECP brakes starting in 2012. The report details how the ECP brakes performed in practice, highlighting the benefits and challenges. The report concludes that the challenges experienced in practice are largely resolved and that there is a business case to expand the use of ECP brakes into intermodal service.

One may question why, if ECP brakes have been widely accepted in Australia, railroads in the United States have not adopted ECP brakes at the same rate. One major factor is that Australian experience a "mining boom", which led to railroads purchasing new cars and locomotives to support this service. Australian railroads used the opportunity to implement ECP brakes, which they believed would produce benefits in the bulk commodity services. FRA believes that this rule, which requires the retrofit of a large portion of the fleet and the purchase of new tank cars presents the same opportunity in the United States. However, regulatory action is necessary in this country because of a perceived insufficiency of business benefits, structural issues (i.e. ownership of cars by shippers rather than railroads), and competing regulatory priorities (i.e. implementation of positive train control (PTC) requirements) have presented hurdles in voluntarily establishing the use of ECP brake technology on unit trains transporting flammable liquids.

Another major factor in the Australian acceptance of ECP brakes is that railroad companies, rather than shippers, own their fleets of railcars, so the benefits and cost of the equipment are captured by a single entity, thereby avoiding the type of market failure described in Section III of this analysis. Indeed, Genesee and Wyoming Inc. (G&W), which operates lines in the United States, Australia, and Europe, has adopted ECP brake systems in its Australian operations but not the United States. There are many differences—in addition to those described above—between the types of operations G&W has in the United States versus those in Australia that inhibit G&W's ability to implement ECP brakes in its United States operations. For instance, in the

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[40] "The ECP Brake—Now it's Arrived, What's the Consensus?," Sismey, B. and Day, L., Presented to the Conference on Railway Excellence, 2014, Adelaide, Australia.

[41] "Oil-by-Rail Shipments Cutting into Coal Deliveries" Cunningham, Nick Oilprice.com, 8/6/14, http://oilprice.com/Energy/Crude-Oil/Oil-by-Rail-Shipments-Cutting-Into-Coal-Deliveries.html

Unites States, G&W is a shortline and regional railroad operator and would handle an HHFUT for only a small portion of its journey. As a result, its decision to equip a train with a certain type of brake is largely determined by the technology used by the interchanging Class I railroad. The G&W operation in Australia is more like a Class I railroad, and it provides an example of the benefits a carrier can attain from using ECP brakes when there is a seamless operation of a single unit train from the originating location to the delivery location while also owning the cars used in such an operation.

We also note that the largest adopter of ECP brakes in the United States is NS, which owns the majority of its coal cars. NS (Norfolk Southern) has extended its ECP brake service within the last three years.[42] In contrast, BNSF hauls ECP-equipped coal cars that are leased by a shipper. BNSF has rebuffed enquiries from the shipper about increasing the size of its leased ECP-equipped fleet and for BNSF to add another train operating using ECP brakes.

PHMSA and FRA researched the quantifiable benefits that Australia has experienced since implementing ECP brakes. Some of the anticipated benefits in our analysis differ from those experienced in Australia due to different operational practices. Because Australia does not have an equivalent safety regulatory body to FRA that would collect data of the safety benefits of ECP brakes, PHMSA and FRA looked to private reports that assessed the success and benefits associated with ECP brakes. The Sismey and Day report discusses the safety benefits of ECP brakes, and it appears that Australians are encouraged by the safety benefit of ECP brakes. The report concludes that the shorter stopping distances and real time monitoring makes them safer than conventional brakes. It specifically notes that "ECP trains can be considered safer in terms of providing real time feedback to the driver on the integrity of the train and also how many wagons are operable and enforcing a stop if the number of wagons operable reduces to less than 85%." Additionally, it notes that "[s]ome have described the shorter stopping distances as a 'get out of [jail] card' as a Signal Passed At Danger (SPAD) incident with a PCP braked train would probably be avoided with an ECP braked train." Additionally, from a safety standpoint, it is ideal to have a system which will not have any brakes that become stuck to the wheel. Australian operators felt that this had been a perennial problem with conventional air brakes, but using ECP brakes had alleviated the problem. The report also detailed that the installation of ECP systems prevented the train from running if the brakes on the last car are cut-out. This is another significant safety feature of ECP brakes. These are just some examples of the safety benefits seen by the Australian carriers.

The Sismey and Day report also interviewed operators, one of whom said, "[g]raduated release is very impressive. This and constant charging are probably the two best features of ECP."

[42] NS added a train that operates using ECP brakes in 2014. This train travels round trip between the Powder River Basin and Macon, GA. It is an NS train—using NS locomotive power and NS-owned cars—and NS performs all of the periodic mechanical brake inspections; however, BNSF assists in operating the train because part of the train's route is over BNSF track.

Another operator commented, "ECP braking allows (and forgives) poor or mismanaged brake applications." Anecdotally, it appears that expectations related to fuel savings in Australia have not matched the estimates used in our analysis. This is because rail carriers in Australia have traded those benefits for other operational improvements (generally higher average speeds and significantly longer trains), indicating that there is an even greater internal benefit from those operational improvements than the carriers would have experienced from reduced fuel. In this way, their estimated fuel savings could understate the benefit. When holding operational conditions constant, fuel savings are expected to be higher than what has been observed. Due to infrastructure limitations, PHMSA and FRA do not anticipate that railroads would operate crude oil or ethanol trains that exceed 140 cars. Per this rule, FRA Emergency Order 30, and the voluntary actions taken by the railroads to limit speeds, higher top speeds are generally not available as a benefit in the United States. In order to allow trains longer than that, sidings would need to be expanded which would be a significant investment. This is an example of how Australia traded fuel saving for longer trains, and explains why such an operational trade-off likely would not occur in the United States.

As mentioned above, Australian railroads have experienced the benefits of ECP brakes, and ECP brake systems have become the preferred method of operation. All new heavy-haul operations in Australia are being planned for and equipped with ECP braking. Many of the overlay systems initially installed in Australia are being replaced by stand-alone ECP brake systems, indicating that the technology is accepted, proven, mature, and effective. ECP braking has been implemented without an Australian government mandate and has been voluntarily adopted by the railroads. Although there has been a learning curve in switching from conventional braking to ECP braking, the positive result of the Australian experience is clear evidence that ECP brake systems are a proven and reliable option for HHFUTs in the United States.

D. Speed Restrictions

1. Regulatory Change

The final rule revises the HMR to restrict all HHFTs to 50 mph in all areas. Further, the regulations will require HHFTs that contain any tank cars not meeting the enhanced tank car standards proposed by this rule operate at a 40-mph speed restriction in high threat urban areas.

2. Overview

High speeds can increase the kinetic energy involved in and the associated damage caused by a derailment. With respect to operating speeds, FRA has developed a system of classification that defines different track classes based on track quality. The track classes include Class 1 through Class 9 and "excepted track," although freight trains transporting hazardous materials currently operate at track speeds associated with Class 1 through Class 5 track and, in certain limited instances, at or below "excepted track" speed limits. Section 213.9 of the FRA regulations on Track Safety Standards provides the "maximum allowable operating speed" for track Class 1 through Class 5 and "excepted track." The speed limits range from 10 mph or less up to 80 mph;

however, AAR design specifications effectively limit most freight equipment to a maximum allowable speed of 70 mph.

In addition, AAR Circular OT-55-N set forth in 2013 a 50-mph maximum speed for any *key train*, including any train with 20-car loads of "any combination of hazardous material." In February 2014, by way of Secretary Foxx's *Letter to the Association of American Railroads*, AAR's Railroad Subscribers further committed to a 40-mph speed limit for certain trains carrying crude oil within the limits of any *High-Threat Urban Area* (HTUA) as defined by 49 CFR § 1580.3.

E. Sampling and Classification Program for Unrefined Petroleum-Based Products

1. Regulatory Change

The final rule requires a written sampling and testing program for all unrefined petroleum-based products, such as crude oil, to address:

1) A frequency of sampling and testing that accounts for any appreciable variability of the material;
2) Sampling prior to the initial offering of the material for transportation and when changes that may affect the properties of the material occur;
3) Sampling methods that ensures a representative sample of the entire mixture, as offered, is collected;
4) Testing methods that enable classification of the material under the HMR;
5) Quality control measures for sample frequencies;
6) Duplicate sampling or equivalent measures for quality assurance;
7) Criteria for modifying the sampling and testing program; and
8) Testing or other appropriate methods used to identify properties of the mixture relevant to packaging requirements.

Further, the provision requires the offeror to certify that a program is in place, document the testing and sampling program, and make program information available to DOT personnel upon request.

2. Overview

An offeror's responsibility to classify and describe a hazardous material is a key requirement under the HMR. In accordance with § 173.22 of the HMR, it is the offeror's responsibility to properly "class and describe a hazardous material in accordance with parts 172 and 173 of the HMR." For transportation purposes, classification ensures that the proper hazard class, Packing Group, and shipping name are assigned to a particular material. The HMR do not prescribe a specific test frequency to classify hazardous materials. However, the regulations in § 173.22 clearly intend for the frequency and type of testing to be based on an offeror's knowledge of the hazardous material, with specific consideration given to the nature of hazardous material

involved, the variety of the sources of the hazardous material, and the processes used to handle and prepare the hazardous material. Section 173.22 also requires offerors to identify all relevant properties of the hazardous material to comply with complete hazard communication, packaging, and operational requirements in the HMR. While the HMR do not prescribe specific requirements to quantify properties relevant to packaging selection, the offeror must follow the general packaging requirements in part 173, subpart B. For example, as indicated in § 173.24(e), even though certain packagings are authorized for a specific HMR entry, it is the responsibility of the offeror to ensure that each packaging is compatible with its specific lading. In addition, offerors should know the specific gravity of the hazardous material at certain temperatures to ensure that outage is considered when loading a rail tank car or cargo tank motor vehicle per § 173.24b(a) of the HMR.

Once an offeror has classified and described the material; selected the appropriate packaging; loaded the packaging; and marked, labeled, and placarded in accordance with the HMR, the offeror must "certify" the shipment per § 172.204 of the HMR. The certification statement indicates the HMR were followed and that all requirements have been met. As such, the offeror is responsible for certifying its material has been properly classified and all packaging requirements have been met. Improper classification can have significant negative impacts on transportation safety. For example, the requirements for safety and security plans required in subpart I of part 172 of the HMR are dependent on Packing Group for many hazardous materials, including flammable liquids. See § 172.800(b)(6).

The physical and chemical properties of unrefined petroleum products are complex and can vary by region, time of year, and method of extraction. Heating, agitation, and centrifugal force are common methods of separation for the initial treatment of unrefined petroleum to reduce the physical and chemical complexities. These methods eliminate much of the gaseous hydrocarbons, sediments, and water from the bulk material. Blending crude oil is another option that can be done in order to achieve a uniform material when other methods are unavailable. However, there may still be considerable variation between mixtures where separation or blending has occurred at different times or locations. While blending may generate a uniform profile for an individual mixture of the material, it does not eliminate the gaseous hydrocarbons or the related hazards. The separation and blending methods both create a new product or additional byproducts that may result in the need to transport flammable gases in addition to flammable liquids. Currently, new state regulations passed December 2014 in North Dakota from the North Dakota Industrial Commission (Oil Conditioning Order No. 25417) will require operators of Bakken crude oil produced in the state of North Dakota to separate the gaseous and light hydrocarbons from all Bakken crude oil that is to be transported. The order also prohibits blending of Bakken crude oil with specific materials. Manufactured goods and refined products, by definition, are at the other end of the spectrum from unrefined or raw materials. This means that the physical and chemical properties are more predictable as they are pure substances or well-studied mixtures.

Crude oil transported by rail is derived from different sources and is most often blended in large storage tanks before being loaded into rail tank cars at transloading facilities. In rare cases, the crude oil is transferred directly from a cargo tank to a rail car, which may result in more variability of properties among the rail tank cars. PHMSA and FRA completed audits of crude oil loading facilities, prior to the issuance of the February 26, 2014 Emergency

Restriction/Prohibition Order, indicated that the classification of crude oil being transported by rail was often based solely on a Safety Data Sheet (SDS). The information is usually generic, provides only basic data, and offers a wide range of values for a limited number of material properties. The flash point and initial boiling point ranges on SDS referenced during the audits crossed the packaging group threshold values making it difficult to determine the proper Packing Group assignment. In these instances, it is likely no validation of the information is performed at an interval that would allow for detection of variability in material properties.

In the case of a flammable liquid (excluded from being defined as a gas per §171.8 of the HMR), the properties needed for proper packing group classification are flash point and initial boiling point. See § 173.120 of the HMR. The offeror may additionally need to identify properties such as corrosivity, vapor pressure, specific gravity at loading and reference temperatures, and the presence and concentration of specific compounds (e.g. sulfur) to further comply with complete packaging requirements.

In addition to the regulations detailing proper classification and characterization of hazardous materials, the rail and oil industry, along with PHMSA input, have developed a recommended practice designed to improve crude oil rail safety through proper classification and loading practices. The American Petroleum Institute spearheaded this effort, resulting in the development of American National Standards Institute (ANSI) / American Petroleum Institute (API) Recommend Practices (RP) 3000, *Classifying and Loading of Crude Oil into Rail Tank* Cars.[43] This API standard, which during its development, went through a public comment period in order to be designated as an American National Standard,[44] addresses the proper classification of crude oil for rail transportation and quantity measurement for overfill prevention when loading crude oil into rail tank cars. While currently not incorporated by reference into the HMR, the development of this document demonstrates that the regulated community realizes the importance of proper classification.

On January 23, 2014, in response to its investigation of the Lac-Mégantic accident, the NTSB issued three recommendations to PHMSA and FRA. Safety Recommendation R-14-6 requested

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[43] The group that developed RP 3000 included a variety of stakeholders representing crude oil producers/suppliers, crude oil purchasers, rail road companies, rail tank car manufacturers, rail tank car lessors, classifiers of crude oil for transportation, crude oil testing laboratories, crude oil testing equipment manufacturers, petrochemical terminal operators and government personnel.

[44] ANSI establishes the consensus procedures that are the basis for the development of American National Standards. ANSI then accredits standards developing organizations that operate in accordance with these procedures, and approve their draft standards provided they are developed via this process. ANSI-approved standards only become mandatory when, and if, they are adopted or referenced by the government or when market forces make them imperative. http://www.ansi.org/about_ansi/faqs/faqs.aspx?menuid=1#stand.

that PHMSA require shippers to sufficiently test and document the physical and chemical characteristics of hazardous materials to ensure the proper classification, packaging, and record-keeping of products offered in transportation. These and other NTSB Safety Recommendations as well as the corresponding PHMSA responses are discussed in further detail in the final rule.

V. Background

PHMSA's mission is to protect people and the environment from the risks of hazardous materials transportation. To do this, PHMSA establishes national policy; sets and enforces standards, educates, and conducts research to prevent train accidents; and prepares the public and first responders to reduce consequences if accidents do occur. Below we describe the NPRM and initial RIA issued by PHSMA to address the growing risk related to HHFTs.

A. NPRM Summary

On August 1, 2014, PHMSA and FRA issued an NPRM, titled *Hazardous Materials: Enhanced Tank Car Standards and Operational Controls for HHFTs*, (79 FR 45015). The NPRM was developed based on comments received in response to the September 6, 2013, advance notice of proposed rulemaking (ANPRM) responding to eight petitions for rulemaking and four NTSB Safety Recommendations related to the transportation of hazardous materials by rail (78 FR 54849) accidents that occurred since the ANPRM was issued, and communications to the agency from the National Transportation Safety Board (NTSB), Congress, and other stakeholders, such as tank car manufacturers, shippers and carriers.

In the NPRM, PHMSA proposed: 1) new operational requirements; 2) improvements in tank car standards; and 3) bolstered requirements for offerors to ensure proper classification and characterization of unrefined petroleum-based products.

These proposed requirements are designed to lessen the frequency and consequences of train accidents involving HHFTs. The proposed changes also address NTSB safety recommendations on the accurate classification and characterization of such commodities, more robust tank car standards, and rail routing. In the NPRM, PHMSA proposed three options for new construction and retrofitting of rail tank cars, as well as three options for a 40-mph speed restriction. In addition to the tank car and speed options, PHMSA proposed four operational controls to reduce the likelihood of derailments and mitigate the consequences should a derailment occur. The proposals are detailed in Table B1 below.

Table B1: NPRM Proposals
New Construction
PHMSA proposed a new DOT-117 tank car to address the risks associated with the rail transportation of ethanol and crude oil and the risks posed by HHFTs (see definition in HHFT section). We analyzed three tank car options for both newly manufactured tank cars and the existing tank car fleet.
Option 1: **DOT and FRA Designed Car**: Incorporates several enhancements designed to increase puncture resistance; provide thermal protection to survive a 100-minute pool fire; protect top fitting and bottom outlets during a derailment; and improve braking performance.
Option 2: AAR Designed Car: Based on the AAR's recommended new tank car standard, approximately 5,000 of which were reportedly ordered by BNSF Rail Corporation. The Option 2 car has

Table B1: NPRM Proposals
most of the same safety features as the Option 1 car, including the same increase in shell thickness, jacket requirement, thermal protection requirement, and head shield requirement, but it lacks rollover protection and the ECP brake equipment.
Option 3: Jacketed CPC-1232: A jacketed CPC-1232 tank car standard, with improvements made to the bottom outlet handle and pressure relief valve. This car is a substantial safety improvement over the current DOT-111 but does not achieve the same level of safety as the Options 1 or 2. This tank car has a 7/16 inch shell, which is thinner than Option 1 or 2 tank cars. This car also lacks rollover protection and ECP brake equipment.
Existing Fleet
Existing DOT-111 tank cars that are used as part of a HHFT may be retrofitted to meet the three Options for the DOT-117 requirements. This retrofit would not include top fittings protections. Alternatively, they could be retired, repurposed, or operated under speed restrictions for up to five years, based on Packing Group assignment.
Speed Restrictions
PHMSA proposed: (1) to establish a 50-mph maximum speed restriction for all HHFTs; (2) to provide three options for a 40-mph speed restriction for any HHFT unless all flammable liquid tank cars meet the enhanced tank car standards; and (3) in the event a rail carrier cannot comply with the enhanced braking requirements, to establish a 30-mph speed restriction for those HHFTs.
Option 1: A 40-mph speed restriction for any HHFT operating in any area unless all flammable liquid tank cars meet the enhanced tank car standards.
Option 2: A 40-mph speed restriction for any HHFT operating in an area that has a population of 100,000, unless all flammable liquid tank cars meet the enhanced tank car standards.
Option 3: A 40-mph speed restriction for any HHFT operating in any high-threat urban area (HTUA)[45] unless all flammable liquid tank cars meet the enhanced tank car standards.
Rail Routing
PHMSA proposed to require the additional safety and security planning requirements prescribed in § 172.820, for HHFTs.
Classification of Mined Gases and Liquids
PHMSA proposed to require a sampling and testing program for Mined Gases and Liquids (referred to as "unrefined petroleum-based products" in the final rule's adopted requirements). This program would be in writing and address the: 1) frequency of sampling and testing; 2) sampling points along the supply chain; 3) sampling methods that ensure a representative sample of the mixture; 4) testing methods to enable complete analysis, classification, and characterization of the material; and 5) statistical justification for sample frequencies.
Enhanced Braking
PHMSA proposed to require advanced braking systems (electronic controlled pneumatic brakes, distributed power, and two-way end of train device) to reduce the number of cars and energy associated with train accidents.
Notification to SERCs

[45] As defined in 49 CFR 1580.3 – High Threat Urban Area (HTUA) means an area comprising one or more cities and surrounding areas including a 10-mile buffer zone, as listed in appendix A to Part 1580 of the 49 CFR.

Table B1: NPRM Proposals
PHMSA proposed to require railroads that operate trains containing one million gallons of Bakken crude oil to notify SERCs or other state approved entities about the operation of these trains through their States.

In the NPRM, PHMSA proposed several revisions to the HMR that would change the specification requirements for rail tank cars authorized to transport crude oil and ethanol. The changes would stipulate a new tank car performance specification, the DOT-117, that would be phased in over time depending on the Packing Group of the flammable liquid. Revising or replacing the current standard for the DOT-111 tank car is not a decision that DOT takes lightly. We provided three tank car options to ensure that the selected tank car will have the greatest net social benefits, with benefits primarily generated from the mitigation of accident severity. The NPRM and initial RIA also clearly noted the large economic effects associated with regulatory changes of this scale, as tank cars are a long-term investment. In Table B2, we clearly indicate the safety features related to each tank car option proposed in the NPRM and the currently authorized tank car.

Table B2: Safety Features by Tank Car Option										
Tank Car	**Bottom Outlet Handle**	**GRL (lbs.)**	**Head Shield Type**	**Pressure Relief Valve**	**Shell Thick-ness**	**Jacket**	**Tank Material***	**Top Fittings Protection****	**Thermal Protection System**	**Braking**
Option 1: PHMSA and FRA Designed Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full-height, 1/2 inch thick head shield	Reclosing pressure relief device	9/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	TIH Top fittings protection system and nozzle capable of sustaining, without failure, a rollover accident at a speed of 9 mph	Thermal protection system in accordance with § 179.18	ECP brakes
Option 2: AAR 2014 Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full-height1/2 inch thick head shield	Reclosing pressure relief device	9/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	Equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Thermal protection system in accordance with § 179.18	DP or Two-way EOT devices
Option 3: Enhanced CPC-1232 Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full height 1/2 inch thick head shield	Reclosing pressure relief device	7/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	Equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Thermal protection system in accordance with § 179.18	DP or Two-way EOT devices
DOT-111A100W1 Specification (Currently Authorized)	Bottom outlets are optional	263K	Optional; bare tanks half height; jacket tanks full height	Reclosing pressure relief valve	7/16-inch-minimum	Jackets are optional	TC-128 Grade B, normalized steel*	Not required, but when equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Optional	EOT device (See 49 CFR part 232)

* For the purposes of this figure, TC-128 Grade B normalized steel is used to provide a consistent comparison to the proposed options. Section 179.200-7 provides alternative materials, which are authorized for the DOT Specification 111.
** Please note that the PHMSA did not propose to require additional top fittings protection for retrofits.

B. Regulatory Review and Notices

Executive Order 12866, "Regulatory Planning and Review," directs all Federal agencies to develop both preliminary and final regulatory analyses if their regulations are likely to be "significant regulatory actions" that may have an annual impact on the economy of $100 million or more. The more recent Executive Order 13563, "Improving Regulation and Regulatory Review" (January 18, 2011) emphasizes careful consideration of costs and benefits and directs

agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible and to proceed only if the benefits justify the costs. This RIA was prepared in accordance with the guidance provided by the Office of Management and Budget's (OMB) Circular A-4[46] on the development of regulatory analysis as required under Section 6(a)(3)(c) of Executive Order 12866, the Regulatory Right-to-Know Act, and a variety of related authorities.

The final rule is an economically significant rule under 3(f)(1) of Executive Order 12866; PHMSA has also designated the rulemaking as a "significant" regulatory action because it is of significant public interest. The rulemaking would also be significant under the Department of Transportation's (DOT) regulatory policies and procedures (44 FR 11034; February 26, 1979).

Title II of the Unfunded Mandates Reform Act of 1995 ("the Act," 2 U.S.C. §1532) requires each agency to prepare a written statement for any proposed or final rule that includes a "Federal mandate that may result in the expenditure by State, local, and Native American Indian tribal governments, in the aggregate, or by the private sector, of $100,000,000 or more (adjusted annually for inflation) in any one year." The value equivalent of $100 million in 1995, adjusted for inflation to 2012 levels, is $151 million. The final rule does not impose enforceable duties on State, local, or Native American Indian tribal governments. The Act was designed to ensure that Congress and Executive Branch agencies consider the impact of legislation and regulations on States, local governments, and tribal governments, and the private sector. With respect to States and localities, the Act was an important step in recognizing State and local governments as partners in our intergovernmental system, rather than mere entities to be regulated or extensions of the federal government.

The final rule would result in costs to the private sector that exceed $151 million in any one year and those costs and benefits associated with this rulemaking have been discussed under paragraph A, Executive Order 12866, Executive Order 13563, Executive Order 13610 and DOT Regulatory Policies and Procedures, of this section. In addition, the RIA provides a detailed analysis of the public sector costs associated with the proposed requirements. The RIA is available in the public docket for this rulemaking. PHMSA invites comments on these considerations, including any unfunded mandates related to this rulemaking.

C. Initial RIA Summary

In the initial RIA, the benefits of the proposed requirements include averted damages from lower-consequence events that do not involve multiple fatalities, and higher-consequence events which involve large-scale property damage and multiple fatalities. Costs include the network

[46] See http://www.whitehouse.gov/omb/circulars_a004_a-4

effects of reducing HHFT speeds, the costs of retrofitting the majority of the current crude and ethanol fleet to meet the new performance standard, and the cost of constructing new tank cars relative to the tank car the industry has committed to building in the absence of regulation. Table B3 provides the benefits and costs for the NPRM proposals.

Table B3: Benefits and Costs of NPRM

Category	Justification	Estimated Damages	
		Average Gallons Spilled per Incident	**Total Societal Damages over 20 Years**
Lower-Consequence Benefits	Avoided costs are based on $300 per gallon of product spilled. As a result, incident severity (property and environmental damage, injuries etc.) is assumed to be correlated with the quantity of product released. Average damages are based on the average quantity released for U.S. crude and ethanol HHFT train mainline derailments.	83,602 gallons	$4.5 billion (Undiscounted)
Higher-Consequence Benefits	The impacts associated with a higher-consequence incident are assumed to be roughly equivalent to those of the Lac-Mégantic derailment. We estimate costs avoided based on a range of high consequence incidents from 0 to 10 events. We assume that one of those 10 events takes place in an area with a population that is five times denser than average. Because U.S. population densities in many areas of the U.S. along crude oil and ethanol routes are significantly greater than those in Canada, incidents in the U.S. may be more severe due to the greater likelihood that larger numbers of people could be affected. For example, the average mid-sized U.S. city (~30,000 or more people) has a population density that is roughly five times or more than that of Lac-Mégantic.	**Estimated Damages**	
		Societal cost	**Total max societal damages**
		$1.2 billion	$14 billion (Undiscounted)
Tank Car Design Standards: Event Mitigation and Cost Estimates	Benefits are based on FRA modelling of the survivability of various tank car configurations relative to one another in the event of a derailment at various speeds. Tank car effectiveness is assumed to be the same for lower and higher-consequence events – e.g., the PHMSA and FRA designed car results in a 51 percent lower probability of release in the event of a derailment than a non-jacketed DOT-111. This car is therefore assumed to reduce the consequences of both higher- and lower-consequence events by 51 percent relative to a train hauling crude or ethanol in non-jacketed DOT-111s.	**Estimated Benefits**		
		PHMSA FRA	**AAR Standard**	**CPC w/ Jacket**
		$822 million - $3.3 billion	$610 million - $2.4 billion	$393 million - $1.6 billion

<table>
<tr><td></td><td>Costs are based on comments to the ANPRM on the cost of retrofitting various features onto an existing car, plus the anticipated cost of a new standard relative to the CPC-1232 with a jacket and thermal protection, which is the car the industry has committed to building for HHFT service in the absence of regulation. In addition, increased fuel use and track wear are monetized because the new standard cars would be heavier and hence result in more fuel use and track wear. Retrofitting legacy cars to meet the new performance standard is the largest cost component of the rule.</td><td colspan="3">Estimated Costs</td></tr>
<tr><td></td><td></td><td>PHMSA FRA</td><td>AAR Standard</td><td>CPC w/ Jacket</td></tr>
<tr><td></td><td></td><td>$3 billion</td><td>$2.6 billion</td><td>$2 billion</td></tr>
<tr><td rowspan="4">40-MPH Speed Restriction:

Event Mitigation and Cost Estimates</td><td rowspan="2">Benefits are based on the same FRA modeling used to estimate the effectiveness of tank car standards in mitigating the consequences of events. They are applied in proportion to the track miles affected and reduced to account for voluntary actions taken on the part of rail carriers (i.e., reduced speed for HHFTs carrying crude oil in HTUAs).</td><td colspan="3">Estimated Benefits</td></tr>
<tr><td>System-Wide</td><td>Cities >100K</td><td>HTUA</td></tr>
<tr><td rowspan="2">The costs of speed restrictions include the effects of traffic slowdowns on crude and ethanol rail corridors. These include slower speeds for both HHFTs and other trains that must reduce speed due to sharing track with HHFTs.
Delay/slowdown costs are monetized at $500 per train per hour of delay.</td><td colspan="3">Estimated Costs</td></tr>
<tr><td>System-Wide</td><td>Cities >100K</td><td>HTUA</td></tr>
<tr><td></td><td>$199 million - $636 million</td><td>$33.6 million - $108 million</td><td>$6.8 million - $21.8 million</td></tr>
<tr><td></td><td></td><td>$2.7 billion</td><td>$240 million</td><td>$22.9 million</td></tr>
<tr><td rowspan="3">Other provisions</td><td rowspan="3">Other provisions include routing, classification and testing, and notification of SERCs. Costs for these provisions are minor compared to tank car and speed costs. PHMSA conducted a breakeven analysis to show the reduction in risk required for the benefits to exceed the costs.</td><td colspan="3">Estimated Costs</td></tr>
<tr><td>Routing</td><td>Class.</td><td>SERCS</td></tr>
<tr><td>$4.5 million</td><td>$16.2 million</td><td>Not estimated</td></tr>
</table>

The options for new and existing tank cars and speed restrictions considered result in nine permutations of the proposed rule. Table B4 presents the costs and benefits of the various combinations of proposed tank car and speed restriction provisions.

Table B4: 20-Year Benefits and Costs of Proposal Combinations of Proposed Regulatory Amendments 2015-2034[47]		
Proposal	**Benefit Range (Millions)**	**Cost (Millions)**
PHMSA and FRA Design Standard + 40 MPH System-Wide	$1,436 - $4,386	$5,820
PHMSA and FRA Design Standard + 40 MPH in 100K	$1,292 - $3,836	$3,380
PHMSA and FRA Design Standard + 40 MPH in HTUA	$1,269 - $3,747	$3,163
AAR 2014 Standard + 40 MPH System-Wide	$794 - $3,034	$5,272
AAR 2014 Standard + 40 MPH in 100K	$641- $2,449	$2,831
AAR 2014 Standard + 40 MPH in HTUA	$616 - $2,354	$2,614
Enhanced CPC-1232 Standard + 40 MPH System-Wide	$584 - $2,232	$4,741
Enhanced CPC-1232 Standard + 40 MPH in 100K	$426 - $1,626	$2,300
Enhanced CPC-1232 Standard + 40 MPH in HTUA	$400 - $1,527	$2,083

VI. Comments on the Initial RIA

PHMSA received over 3,200 public comments representing over 182,000 signatories in response to the August 1, 2014 NPRM and initial RIA. The final RIA summarizes comments specific to the derivation of costs and benefits of the rulemaking proposals and has been revised to align with the changes made to the final rule. Adjustments to the methodology used to estimate the benefits and costs resulting from the final rule are explained in subsequent sections.

A. Comments Related to the Benefits

Baseline Damages

In the initial RIA, PHMSA defined a baseline assessment of future damages associated with derailments of crude oil and ethanol trains in the absence of additional regulation. These damages include estimates of the number of derailments and the damages from those derailments, which can include product releases, property and environmental damage, injuries, and fatalities. To estimate the number of derailments per million carloads shipped, PHMSA used a combination of FRA's derailment database and the public waybill sample to construct a historical series on annual derailments. To determine the average amount of product released and damages associated with derailments, PHMSA utilized the FRA derailment database and the

[47] All costs and benefits are in millions, and are discounted to present value using a 7 percent rate.

PHMSA hazardous materials incident report database. In the initial RIA we asked readers a series of questions regarding the estimates of the number of derailments per year and the average product released per derailment. We also requested additional information regarding the difference in the probability of a derailment involving crude oil versus ethanol and improvements in data collection methods that could inform the baseline assessment.

In a joint submission, Riverkeeper and Scenic Hudson comment that PHMSA's benefits analysis emphasizes accidents in HTUAs. They further state that an oil spill on the Hudson River would be impossible to clean up completely, and would have long-term environmental damages beyond those considered by PHMSA. Several commenters suggest that DOT should focus more on the root causes to prevent accidents. Several other commenters made similar statements regarding the root cause of accidents.

PHMSA Response
PHMSA and FRA focus on prevention, mitigation, and response to manage and reduce the risk posed to people and the environment by the transportation of hazardous materials by rail. When addressing these issues, PHMSA, and FRA focus on solutions designed to reduce the probability of accidents occurring and to minimize the consequences of an accident should one occur.

PHMSA and FRA have used a variety of regulatory and non-regulatory methods to address the risks of the bulk transport of flammable liquids, including crude oil and ethanol, by rail. These efforts include issuing guidance, conducting rulemakings, participating in rail safety committees, holding public meetings, enhancing enforcement efforts, and reaching out to the public. All of these efforts are consistent with our system-wide approach. Train accidents are often the culmination of a sequence of events that are influenced by a variety of factors and conditions. While the Final Rule does not directly address regulations governing the inspection and maintenance of track, securement, and human factors, it does indirectly address some of these issues through the consideration of the 27 safety and security factors as part of the routing requirements. PHMSA and FRA find that existing regulations and on-going rulemaking efforts—together with the amendments in this Final Rule relating to speed, braking, and routing—sufficiently address safety issues involving rail defects and human factors.

Comment
API and the Illinois Commerce Commission commented that PHMSA used derailment data from all commodities and from all track data—mainline, yard, siding and industry—which overestimates the number of incidents used in the trend calculation. API believes PHMSA should only use mainline derailments that release the hazardous materials being regulated with this rule. The Mercatus Center cites results from its own analysis that indicates that the number of rail carloads of crude oil grew much faster than the number of accidents involving these cars, indicating that the accident rate for crude oil rail shipments was actually declining. DGAC also submitted comments noting that the accident rate has been declining. American Fuel & Petrochemical Manufacturers (AFPM) note that in the benefit calculation for the tank car standards, PHMSA only analyzed crude and ethanol derailments and the effect that new and retrofitted cars could have on preventing such incidents. Therefore, PHMSA should conduct a separate analysis to determine the effects of the tank car standards for other flammable liquids in a separate rulemaking process.

PHMSA response
In the final rule, PHMSA revises the HMR to establish requirements for any "high-hazard flammable train" (HHFT) that is transported over the U.S. rail network. This rule defines an HHFT as a train comprised of 20 or more tank car loads of a Class 3 flammable liquid in a continuous block or 35 or more tank car loads of any Class 3 flammable liquid across the entire train. The rule ensures that the requirements are closely aligned with the risks posed by the operation of trains that are transporting large quantities of flammable liquids. While Mercatus and DGAC note that the number of carloads increased at a faster rate than derailments, they fail to note that prior to 2011 relatively few shipments of crude oil were made by rail and that we still have only a few years of high volume shipments.

PHMSA remains focused on the unique risks associated with trains consisting of large blocks of hazardous materials. Crude oil and ethanol are the only types of commodity frequently transported in this configuration. The approach used for the final RIA is adjusted to accommodate these comments by focusing on derailments on mainline and siding track involving crude oil and ethanol.

Comment
The NYU School of Law Center for Policy Integrity commented on PHMSA's cost per gallon spilled estimates that were based on the Lynchburg, VA, accident. It did not offer additional data or analysis, but suggested that the Agency should calculate this cost as an average over several incidents. It also expressed the opinion that the costs reported in the Lynchburg case may be underreported. Conversely, PHMSA received comments that the cost per gallon spilled may be overstated. API commented that PHMSA chose to use cost data associated with the Lynchburg, VA incident, despite having data from 40 mainline derailments involving crude oil and ethanol releases since 2006. The average cost, including Lynchburg, from 2006 to 2013 is $16.67, yet Lynchburg, which had a cost of $300 per gallon, was used.

PHMSA response
PHMSA examined news and railroad reports from two crude oil incidents for which cost estimates are at least preliminarily available, evaluated cost estimates prepared by the NTSB, reviewed cost estimates reported by railroads to PHMSA in hazardous material incident reports for both ethanol and crude oil, and consulted academic literature on the cost of responding to ethanol and crude oil spills exceeding $300 per gallon in some cases. This research suggests that the response and cleanup costs for an individual spill of both crude oil and ethanol vary greatly and are influenced by a variety of factors including the amount of product released, topography, soil type, oil type and whether or not the material entered a waterway. After performing this research, PHMSA has decided to use a cost per gallon value that weights the costs associated with crude oil and ethanol spills and weights the costs by forecast future volume for each commodity. The central estimate for ethanol spills is $144, and the central estimate for crude oil spills is $211. We estimate the weighted average based on the percentage of crude oil and ethanol in the future carload forecast, resulting in a value of approximately $200. The Agency uses separate per gallon cost estimates—for both crude oil and ethanol—that are based on the available data and literature, and then unifies these figures into one figure by applying weights to each figure in proportion to the volume of each commodity expected to be shipped over the next 20 years.

Comment
Hess notes that the draft RIA calculates the benefits of the rulemaking based on assumptions regarding the volatility of Bakken crude oil. Hess disagrees with any assertion or implication that the characteristics of crude oil produced in the Bakken are substantially different than the characteristics of other light, sweet crude oil produced in the United States. Similarly Great Northern Midstream states that studies indicate that the Bakken crude oil is less volatile and less corrosive than most oils produced in the U.S. and globally, but that the NPRM has continued to include this perception in the rules it is proposing.

PHMSA response
PHMSA discusses the relative characteristics of crude oil and ethanol in derailment scenarios later on in this document. The Literature Survey of Crude Oil Properties Relevant to Hanling and Fire Safety in Transport, prepared by Sandia National Laboratories examines the properties of tight crude oils as they relate to potential combustion events in the rail transport environment.[48]

Comment
Great Northern Midstream states that avoided harm and benefits in the NPRM are overstated because of the overstated frequency of future train accidents (14.36 expected accidents in the first year of the analysis, declining to 5.16 in the last year) and the overstated costs per accident ($1.2 billion to $6 billion depending on accident size) used in PHMSA's analysis, among other purported flaws. When more realistic assumptions are used (e.g., since 2006, the average is 2.2 train accidents per year at $5 million per accident), and the appropriate data are properly analyzed, some commenters hold that the costs of complying with the rules and the costs to the rail industry and the economy as a whole from the rulemaking exceed the avoided harm or benefit of the NPRM by a large measure.

PHMSA response
PHMSA discusses its methodology for developing its baseline level of damages expected in the absence of the rulemaking. PHMSA assumed that the downward slope of the derailment trend for all commodities reflects increasing safety for rail cargo transport of all commodities. The estimates PHMSA bases the costs associated with a derailment of crude or ethanol on the average amount of product released when a derailment occurs. As described later on, we do not believe that the reported total damages associated with derailment events appropriately captures the total societal damages. The total damages of a spill will depend not only on the size of a spill, but also where it occurs, the type of material spilled, and the circumstances of the accident. There is likely to be more property damage if a spill occurs in a densely populated area or if it results in a fire. There is likely to be more environmental damage if the spill occurs in an

[48] The full report may be accessed through the following url: http://energy.gov/fe/articles/sandia-national-laboratories-releases-literature-survey-crude-oil-properties-relevant

environmentally sensitive area. Costs of cleanup may be higher for heavier crude oil that does not burn.

Comment
AAR commented on how PHMSA calculated the marginal benefits of the enhanced rail tank cars it would be mandating. PHMSA uses the current fleet as its baseline, but AAR contends that PHMSA uses a baseline that assumes most rail tank cars are "legacy" DOT-111s. Similarly, GWU states that PHMSA did not include in its baseline an expectation that, due to market forces, Option 3 tank cars will become widely used for the transport of flammable liquids in the future. Therefore, measuring increases in efficacy against DOT-111 tank cars, rather than Option 3 tank cars, will overstate the efficacy of PHMSA's rule.

PHMSA response
As discussed in the baseline fleet projection, later in this document PHMSA's analysis reflects that roughly 34 percent of rail tank cars would be jacketed CPC-1232 tank cars in the absence of regulation and adjusts baseline damages accordingly. This addresses the issue AAR raises with regard to the fleet composition in the future having a greater portion of jacketed CPC 1232s. The Agency did not assume that all rail tank cars would be "legacy" cars when considering expected future damages from crude and ethanol incidents. Future damages were adjusted downward in proportion to the jacketed CPC 1232's expected safety improvement and the portion of the fleet expected to be made up of jacketed CPC 1232s. A similar adjustment to the baseline damages was done at the NPRM stage, contrary to AAR's assertion that no adjustment of expected damages were made due to voluntary actions on the part of the industry.

Comment
In a combined submission from the Center for Biological Diversity, Friends of the Gorge, and the Adirondack club, commenters state that PHMSA understates the extent of the problem by estimating a range of future avoided accidents based on data from 2006 to 2013. These commenters suggest that PHMSA should extrapolate upward from the point at which crude oil accidents spiked in 2013, and thereby assume an increase in the number of these accidents.

PHMSA response
PHMSA focuses on derailments of crude oil and ethanol trains from the most recent five years of data. We continue to believe this is an appropriate time period from which to project the frequency of future derailments. The relatively infrequent nature of derailments of trains containing flammable liquids limits the sample size, and the number of derailments is subject to significant variation from one year to the next, so projecting future derailments from a single year, such as 2013, may not adequately represent future expected events. This time frame is fairly short but the advent of high quantities of crude oil shipped by rail was 2011 or 2012, so few years of data exists in which crude oil has been shipped in anything resembling the quantities forecast going forward. PHMSA selected this timeframe because it balances incorporating the years that best represent of crude and ethanol volumes going forward with a sufficient number of years to capture variations in the data reasonably well.

Higher-Consequence Damages

In order to consider the full impacts of this rule, it is necessary to examine the potential for HHFT accidents greater in number or severity than those observed to date in the U.S. While there have been no higher-consequence events in the U.S., we believe that such an event is possible. We considered whether, in addition to the accidents observed in the baseline, one or more higher-consequence events could occur in the absence of the regulation. These events exceed the "typical" derailment event because they would result either in multiple fatalities or injuries, or would cause greater environmental damages than a typical derailment. The upper bound for the damages resulting from any one particular event was described as five times as great as the damages resulting from the event that occurred at Lac-Mégantic, Quebec, adjusted for the track weighted population density along U.S. crude oil and ethanol routes. In the initial RIA we presented figures for zero events and ten events and the associated undiscounted damages. As explained above, we assume that one of those ten events takes place in an area that is five times denser than average.

Comment

Mercatus questions the reliance on a high-consequence event (Lac-Mégantic) for calculating benefits. RSI states that PHMSA's analysis "overstates the likelihood of extra-ordinary events like Lac-Mégantic." AAR comments that the basis for PHMSA's pool of benefits from catastrophic events—9 events with costs exceeding $1.15 billion and one exceeding $5.75 billion—is purely speculative. They state further that there has been only one catastrophic event. AAR calculates that PHMSA's catastrophic event assumptions are equivalent to 0.56 catastrophic events per million carloads, and if this were the case, multiple catastrophic events would have already occurred.

Growth Energy states that the Lac-Mégantic incident is an isolated incident that the new tank car specifications will not address; and that PHMSA overestimates the likelihood of a high-consequence derailment event in the U.S., the likely harm of such an incident, the environmental remediation cost associated with a lower-consequence incident. They also state that PHMSA fails to account for the fact that many derailments do not involve a spill.

PHMSA response

As discussed in more detail in the high consequence event damage section, PHMSA projected higher consequence events over the next twenty years in the absence of the rule. This figure rule based on carloads shipped and an estimate of expected carloads over the next 20 years. PHMSA revised its estimation for the number of events over the next 20 years that could potentially lead to catastrophic damages from the NPRM. In the model, the number of events and the severity was permitted to vary, thus accounting for the inherent uncertainties in projecting damages from unlikely events. Many of the provisions in this rule including improved tank car integrity, proper classification and characterization of materials, speed restrictions, routing analyses and braking are intended to decrease the potential of rail accidents and mitigate the consequence of an accident should one occur. PHMSA based its estimates of the damages associated lower consequence events, i.e. deaths, injuries and environmental and property damages, emergency response costs resulting from lower-consequence events, based on an examination of the historic accidents that include accidents with little to no product release.

Comment
API commented that PHMSA provided insufficient explanation or justification about the number of events it has chosen to model. API also states that PHMSA calculated a range from zero to ten, with ten as the upper bound, but only provided data for the upper bound case. API also criticizes key characteristics of the Lac-Mégantic incident as making it unsuitable to extrapolate from. It cites the fact that PHMSA uses the speed of 65 mph in the Lac-Mégantic accident to calculate the estimated damages for nine of the higher-consequence events, despite its own recognition that the speed of the train and the number of cars derailed are not likely to be seen in the U.S, given the agreed upon speed limit of 50 mph for crude and ethanol unit trains. Further, API adds that the U.S. has never experienced a derailment of more than 31 cars. API comments that another flaw with the agency's logic is that they provide only a point estimate of the potential damages of nine Lac-Mégantic size incidents under the higher-consequence event discussion.

Bridger also states that the incident that occurred at Lac-Mégantic, Quebec was atypical, and that regulatory intervention that is underway at this time by FRA would cause such an incident to not be replicable in the U.S. Further, Bridger contests the premise that the previous losses at Lac-Mégantic, Quebec, are usable for projecting future losses in the U.S. in light of intervening and pending regulatory actions.

The Renewable Fuels Association (RFA) also commented on extrapolating from the Lac-Mégantic Incident to calculate benefits, and states that the inclusion of data from that event still fails to adequately demonstrate that the rule will have positive net benefits. RFA also states that none of the rail car upgrades proposed would have prevented this incident, and that it is "disingenuous to use this human error caused [by a] preventable event to make a point about the ethanol tank car upgrade benefits."

PHMSA response
PHMSA does not mean to suggest that the provisions of this final rule are intended to address the events that led to the accident at Lac Mégantic, Quebec. PHMSA used the Lac-Mégantic event, which did occur in Canada, only to provide a cost estimate for a low-probability/high-consequence event that *could* occur in the U.S. given the increase in total carloads of crude and ethanol shipped in HHFTs. PHMSA looked to the estimated damages of the accident at Lac-Mégantic, Quebec to illustrate the potential benefits of preventing or mitigating higher-consequence events. We acknowledge that there is uncertainty about the potential magnitude, since there has only been one such event in North American rail history. PHMSA considered the comments and scaled down the damages from Lac Mégantic to account for a smaller expected number of cars derailed and lower speeds. This model, its methodology and assumptions are detailed in the section called Higher Consequence Event Damages. Additionally, in its final rule PHMSA acknowledged the August 9, 2014 NPRM that proposed amendments to strengthen the requirements relating to the securement of unattended equipment.

Prioritize Regulatory Action to Address Crude Oil and Ethanol Separately

In addition to cleanup costs, RFA requested that PHMSA differentiate between ethanol and crude oil because the commodities do not share the same chemical composition. Further, RFA commented that PHMSA should not prioritize crude oil and ethanol together. The final rule has

adopted a retrofit timeline that takes a tank car/Packing Group approach to addressing the risks associated with flammable liquids in HHFTs. The approach provides a longer retrofit timeline for a flammable liquid in Packing Group II, than a flammable liquid in Packing Group I. FRA performed analysis of the documented damage to tank cars exposed to pool fire conditions following a derailment of trains that consisted partially or entirely of tank cars containing fuel ethanol and crude oil. The purpose of the analysis was to understand the relative hazards of fuel ethanol and crude oil and their potential to cause catastrophic failure of tank cars in pool fire conditions. Much has been made of the effect of volatility of crude oil on hazards, especially crude oil from the Bakken shale play in the Williston Basin. An important safety policy question currently under debate is whether the increased volatility renders crude oil involved in a derailment more explosive than other flammable liquids necessitating special classification and packaging. The North Dakota Industrial Commission Oil Conditioning Order No. 25417 (the Order) requires Bakken crude oil operators in the state of North Dakota to separate the gaseous and light hydrocarbons from all Bakken crude oil. The Order also prohibits blending of Bakken crude oil with specific materials.

FRA developed and implemented procedures to carefully document damage to each tank car involved in derailments. The fruit of this effort is a catalog of damage to tank cars, specifically DOT-111 tank cars transporting flammable liquids, which can be utilized to understand the behavior/performance of protective design features. Further, vulnerabilities of the specification can be identified and design enhancements evaluated. Data, in the form of photographs, assessment forms and narrative descriptions of damage to all tank cars (containing fuel ethanol and crude oil) involved in derailments and exposed to pool fire conditions was organized and evaluated. First, the damage was evaluated relative to tank car vintages and features to determine if damage could be attributed to these features. Then damage was evaluated relative to the commodity to provide a qualitative relative hazard of the commodities under consideration.

The overall conclusion from this analysis is that: 1) there was no discernable correlation between design features of the tank cars and the damage to the tank cars exposed to pool fires; and 2) fuel ethanol poses a similar, if not greater, risk as crude oil when released from a tank car that fails catastrophically, resulting in a large fireball type of fire with or without an explosion. Further, the properties of the flammable liquids and handling of the cars in large blocks or unit trains presents a unique hazard in that, if released and ignited, the fire will affect adjacent cars. Moreover, adjacent cars will likely, if not certainly in the case of a unit train, contain the same flammable liquid and result in releases of more flammable liquid through the pressure relief valve or a catastrophic failure of the tank. A catastrophic failure involved either a tear in the tank or a violent rupture that nearly or completely separated portions of the tank. Accompanying these failures have been the resulting fireball-type fire (deflagration) and, in some cases, blast wave (explosion) effects. See Figure 6.

Figure 6: Photographs of explosions at recent derailments; Arcadia, OH (fuel ethanol); Casselton, ND (crude oil), and Plevna, MT (fuel ethanol)



The data does not indicate any causal relationship between the attributes of the tank car, pressure relief valve (PRV), location in train, or other attributes and the occurrence of the thermal damage. In other words, the data does not suggest that something other than the commodity could explain the observed thermal damage. Fuel ethanol provided the basis for a relative risk analysis of crude oil. Like fuel ethanol, crude oil is transported in large block trains or unit trains and is classified as a flammable liquid. Fuel ethanol is a Packing Group II material. Crude oil can be a Packing Group I, II or III. Crude oil from the Bakken shale play is typically a Packing Group I material. The available evidence does not suggest that the relatively higher volatility of crude oil (Bakken) has any meaningful impact on the thermal damage that occurs to tank cars during derailments. The documented performance of the tank cars containing these materials involved in derailments and exposed to pool fire conditions provides an objective means to compare the effects of certain properties of these commodities on the survivability of tank cars exposed to pool fire conditions.

The separations[49] (higher energy events) occurred in tank cars containing fuel ethanol.

1) The same number of thermal tears[50] occurred in tank cars containing fuel ethanol as cars containing crude oil.
2) The number of cars involved in derailments in which thermal tears and separations were encountered was nearly equal for fuel ethanol (107) and crude oil (109).

[49] A separation occurs when a thermal tear propagates circumferentially from each end of the tear and result in the tank completely or nearly fragmenting into multiple pieces.

[50] A thermal tear is typically a longitudinal failure that occurs in the portion of the shell surrounding the vapor space of the tank following exposure of the tank to pool fire conditions. The tank shell fails when the pressure in the tank (and resulting tensile or hoop stress) exceeds the tensile strength of the shell materials that is diminishing with time of exposure to the pool fire. The length of thermal tears measuring during FRA investigation ranges from 2-16 feet. The length of the tear may be a function of the volume of vapor escaping through the failure, flaws in the shell material, and the existence of crack arresters such as welds or stronger, non-heat effected steel.

3) A variety of factors that could have influenced the likelihood of thermal damage were analyzed, including the steel specification, start to discharge pressure, age of car, lading, flow capacity of PRV, location of cars in derailment, and location in the train of the first car to derail.

There is little evidence supporting the position that crude oil (especially that extracted from the Bakken region) poses a heightened risk of a high energy or explosive event when tank cars containing the material are exposed to pool fire conditions. In fact, the failure rate (due to thermal damage) of tank cars containing fuel ethanol is 1.5 times greater than that of a tank cars transporting crude oil.

Literature Review of Impacts of Spills of Crude Oil and Ethanol

The amount of crude oil transported by rail has increased significantly over the past 5 years in the United States, both for originated and terminated carloads. Unlike pipelines, rail transport can offer geographic flexibility and responsiveness to meet the needs of new suppliers and customers looking for quicker ways to transport large shipments (Association of American Railroads). A list of literature reviewed on the cost of spills is in Appendix B.

Research shows that large oil spills can have an impact on trade, tourism, the environment and/or wildlife in the surrounding region immediately after a spill and in the long-run. However, in the event of an oil spill, the responsible party is not initially the sole bearer of costs that arise from the spill. Rather, government agencies, businesses, and individuals incur an array of external costs as a result of the direct and indirect impacts of the oil spill. In "A Taxonomy of Oil Spill Costs: What are the Likely Costs of the *Deepwater Horizon* Spill" Mark Cohen notes that oil spills costs can include: containment and cleanup costs borne by the Federal and local government, costs of repairing public infrastructure, natural resource damages, lost income from affected businesses, lost consumer value from shifting purchases and behavior, and ligation costs. Krupnick, Campbell, Cohen, and Parry note that lost profits is the appropriate measure to assess costs to local industries that directly suffer as a result of a spill. However, the extent to which businesses are compensated for the losses depends on how well they are able to legally document their claims.[51]

Cleanup costs can be broken down into two categories: (1) labor costs and (2) equipment costs for supplies and tools needed to clean up the oil spill. Marruffo, Yoon, Schaeffer, Barkan, Saat, and Werth (627–632) estimated the number of hours required to clean up a railcar oil spill for four different substances: E95, gasoline, crude oil, and diesel fuel. This model suggests that E95 takes the least amount of time to clean up and the longest cleanup time was for diesel fuel. They

[51] Krupnick, Alan, Sarah Campbell, Mark Cohen, and Ian Parry. *Understanding the Costs and Benefits of Deepwater Oil Drilling Regulation.* Washington, DC: Resources for the Future, 2011

also differentiated by the type of soil where the oil is spilled, finding significantly different cleanup times for coarse sand, fine sand, and silt. Ethanol spills tend to have lower cleanup costs compared to other types of oil due to its higher solubility, as noted by Child et al. in the report for the Massachusetts Department of Environmental Protection, which details the impacts and response strategies for ethanol spills.

Random utility models are a common analysis technique used to estimate recreational losses people face as a result of oil spills. In the oil spill cost literature, studies typically used either contingent valuation or hedonic valuation techniques. Specifically, most of the studies employed the same willingness-to-pay or travel cost theoretical concepts and primary data collection surveys of a sample of the affected population. Studies using hedonic price estimation commonly assessed property values to estimate how an oil spill could change people's preferences for the same house and land. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), travel cost and contingent valuation methods are officially confirmed as acceptable methods for estimating the costs of damages due to the release of hazardous materials in publicly owned habitats in water and on land.

Several other studies valued the costs of oil spills by estimating the cost per gallon of oil spilled. This technique allows for some comparison across different oil spill events to gauge the severity of different incidents. However, it is important to keep in mind that each oil spill incident is unique, and therefore the degree of costs incurred are subject to the severity of each spill and the spill characteristics (e.g., location and oil type). The estimated per gallon costs from numerous studies are presented in the table below. All estimates are in 2013 dollars, as they were adjusted for inflation using the GDP deflator index.

Table C1: Dollar Per Gallon Estimates by Study

Study	Per Gallon Estimate	Oil Type
Marruffo (2012)[1]	$378.34	Crude
Cohen (2010)[2]	$892.29	Crude
Cohen (1986)[3]	$6.59	Crude / Fuel Oil
Helton and Penn (1999)[4]	$262.26	Crude / Fuel Oil
U.S. Coast Guard (2011)	$271.00	Crude / Fuel Oil
U.S. Coast Guard (2003)	$385.00	Crude / Fuel Oil
U.S. Coast Guard (2013)	$453.33	Crude / Fuel Oil
Etkin (2003)	$633.71	Crude / Fuel Oil
NTSB Tiskilwa, IL (2013)	$6.38	Ethanol
Marruffo (2012)1	$8.22	Ethanol
NTSB New Brighton, PA (2008)	$9.88	Ethanol
NTSB Columbus, OH (2014)	$13.48	Ethanol
NTSB Cherry Valley, IL (2012)	$19.53	Ethanol
NTSB Casselton, ND (2013) – preliminary	$15.25	Crude
Saat et al. (2014)	$144.00	Ethanol

1 Value represents only the labor cleanup cost; other cost factors are not included.
2 Value is an average from the study's estimated range of $543.27 to $1,241.30.
3 Weighted by percent of spill that directly impacted fishing industry, water supply, birds, and recreational activities.
4 Value is an average per gallon estimate from 29 specific spill incidents.

B. Comments Related to the Costs

PHMSA received many comments regarding the capability of the industry to comply with the proposed retrofit schedule, the key assumptions pertaining to the costs of retrofits, and the possible repurposing of existing tank cars to other flammable liquid service. Many questioned PHMSA and FRA's assumptions on the retrofit capacity of the industry. Overall, commenters agree that retrofits must occur, but the suggested timelines range from zero to ten years. In addition, RSI and API commissioned separate reports that evaluated the NPRM's proposed timeline and demonstrated the potential detriment of an overly aggressive timeline.[52] PHMSA has summarized and discussed below the differing viewpoints on the retrofit schedule.

RSI, API, Exxon, APFM and many others in the regulated industry provided specific alternative retrofit timelines which can be viewed in the docket for this rulemaking. RSI-CTC states that PHMSA and FRA should retrofit crude oil and ethanol tank cars first and then other Class 3 tank cars. They estimated that retrofit capacity is only 6,400 units per year, whereas PHMSA assumes 22,061 units per year in its NPRM. RSI continues, "there are 50K non-jacketed tank cars in service (23K crude and 27K ethanol/legacy and CPC-1232) that cannot be retrofitted by 10/01/2017—only 15K can be retrofitted by that time." With an even more conservative estimate, Alltranstek, on behalf of API, estimated a range of 2,430 to 3,000 tank cars that could be retrofit per year in its "base case." In addition, RSI, Archers Daniel Midland, Arkema, and others stated that PHMSA did not consider the highway congestion, emissions, and safety impacts of a shift to highway transportation, should PHMSA's compliance schedule constrain the availability of rail tank cars for transporting hazardous materials. Arkema also expressed concerns that the cost of additional regulations themselves could make rail a less competitive option for shipping hazardous materials, which could lead to more reliance on trucks.

The NYU School of Law Center for Policy Integrity suggested that PHMSA should consider the costs of countervailing risks. This commenter mentions that reduced speed limits increase the amount of time HHFTs spend in proximity to HTUAs and environmentally sensitive areas; and that increased rail tank car weights will add stresses to railway infrastructure, particularly bridges owned by non-Class I terminal railroads.

Phillips 66 cites that the compliance schedule could result in rushed deliveries of retrofit cars. This could result in lower safety outcomes than those calculated by PHMSA.

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[52] The Railway Supply Institute, committee on tank cars commissioned the Brattle group to review PHMSA's initial RIA. Additionally, the American Petroleum Institute commissioned ICF to conduct a review of the economic impacts of PHMSA's NPRM.

The Illinois Commerce Commission, RSI, API, Cenovo, Arkema, and others question the assumption that no retirements would occur as a result of this rule, or that retirements would be avoided due by transferring non-compliant rail tank cars to Canada tar sands service.

PHMSA received a range of comments asking that it consider an immediate ban or other expedited discontinuance of all DOT-111 tank cars for crude and ethanol transport. Specifically, the Center for Biological Diversity, Friends of the Gorge, and the Adirondack club urged that PHMSA immediately ban the use of DOT-111 tank cars used for the rail transport of flammable liquids. PHMSA notes that an immediate ban of DOT-111 tank cars, as The Center for Biological Diversity, et al. recommended, would result in thousands of truck shipments of crude oil and ethanol. PHMSA considered the impacts of immediately banning the use of the DOT-111 tank car in HHFTs. However, an immediate ban of the DOT-111 tank car is not a reasonable alternative because affected industries could not replace rail cars immediately and would not be able to immediately switch to other transportation modes. This would cause supply chain disruptions, increased shipping costs, and increased reliance on trucks to make up for lost transport capacity. This increased reliance on trucks could have detrimental environmental and safety implications. As such, PHMSA concluded that an immediate ban or other expedited discontinuance of all DOT-111 tank cars for crude and ethanol transport is not a reasonable alternative. Therefore, PHMSA more fully examined the impacts of a schedule that would phase out the use of all DOT-111 tank cars in PG I and PG II service by 2018.

PHMSA weighed the benefit of reductions in releases from rail accidents that would result from the 2018 removal of DOT-111 tank cars against increased air pollution and highway accidents, often resulting in releases, that would result from a temporary modal shift, along with extremely high cost to industry and the public, and the other regulatory provisions in this rulemaking that are also aimed at reducing derailments and releases. The retrofit timeline selected in the final rule provides a longer timeline proposed at the NPRM stage. In developing the retrofit schedule, PHMSA and FRA examined the available shop capacity, the comments received, and the potential impacts associated with the retrofit schedule. PHMSA examined the impacts of the potential shift from rail to highway as a result of an overly aggressive retrofit schedule. A faster retrofit schedule could result in fewer tank cars available to ship crude oil and ethanol than production requires. If the deficiency in cars is substantial, shippers will employ other modes of transportation. The customers for crude oil and ethanol rail shipments are spread throughout the U.S. and Canada, and thus the diversion to other modes of transportation is likely to involve substantial numbers of additional trucks carrying flammable liquids. This would result in a decrease in safety, as trains have a much lower accident frequency than trucks when adjusted for the volume shipped. Upon consideration of all these factors, PHMSA recognizes the need to upgrade the rail car fleet, but found that a targeted phase-out of the DOT-111 tank cars was the most prudent and protective approach. As a result, the selected retrofit timeline option indicates that there would be no additional reliance on highway transportation.

PHMSA has accepted feedback regarding its assumption of no retirements and the impracticality of transferring jacketed tank cars to oil sands service. This RIA now considers the number of cars that could be retired early as a result of the rule and the associated costs of doing so. PHMSA believes that rail cars will be retired early when their owners have weighed the cost of meeting retrofit requirements against the marginal cost of acquiring a replacement rail car early.

More specifically, when the discounted replacement cost of a new car is less than the cost to retrofit an existing car, then owners will opt to retire a non-compliant car early.

Further, to aid in the analysis of an appropriate retrofit timeline, FRA developed a model to project the tank car retrofit capacity over time. The model is based on Wright's learning curve theory, which posits that every time the number of units produced doubles the cost of production will decrease by a given percentage[53]. This percentage is known as the learning rate. The first step in developing the model was to reproduce the rail industry's forecast in the Brattle Group Report to accurately identify the capacity for "heavy retrofits" (heavy retrofits include those that go beyond simply adding a valve and bottom outlet to the jacketed CPC-1232 cars). As indicated in the Brattle Report, FRA allowed for a retrofit capacity ramp-up to 6,400 heavy retrofits per year. FRA's model indicates that 40 tank car repair facilities are presently able to dedicate one crew to these retrofits.

Once the industry forecast line was produced (Figure 7), FRA applied variables for the learning rate, number of crews, and number of facilities. The intent was to depict the extent to which the heavy retrofit capacity will increase to a degree over time. The values for these variables in the model are a learning rate of 0.95 (which is relatively low for similar industries[54]), one crew (initially) per facility, and 40 facilities. Using these values as the starting point a parametric analysis was performed to show the values required to meet the retrofit timeline.

As a result, the remaining capacity (around 60 facilities identified by FRA) would focus on the normal workload, including requalifications, bad order repairs, and reassignments. Further, FRA identified 160 tank car facilities capable of performing light modifications, which include adding a valve and bottom outlet to the jacketed CPC-1232 cars. FRA also accounts for industry concerns regarding the readiness of current tank car facilities to perform retrofit services by maintaining the ramp-up period provided by commenters. Other key model assumptions are provided below:

1) A new crew (2 employees) will be added at each facility every 3 months, beginning in month 4 and continuing to month 24.

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[53] Wright, T.P., "Factors Affecting the Cost of Airplanes", Journal of Aeronautical Sciences, 3(4) (1936): 122–128.

[54] It is recognized that repetition of the same operation results in less time or effort expended on that operation. For the Wright learning curve theory, the underlying hypothesis is that the direct labor man-hours necessary to complete a unit of production will decrease by a constant percentage each time the production quantity is doubled. If the rate of improvement is 20% between doubled quantities, then the factor known as the learning percent, would be 80% (100-20=80). While the learning curve emphasizes time, it can be easily extended to cost as well. The learning percent is usually determined by statistical analysis of actual cost data for similar products. http://www.csgnetwork.com/learncurvecalc.html

2) It is expected that productivity will improve throughout the retrofit period with similarly trained employees using the same tools and equipment.
3) Based on Wright's learning curve theory, every time production doubles, the required resources and time will decrease by a given percentage, known as the learning rate. The learning rate coefficient for repetitive welding operations is 0.95.
4) After 24 months, no additional resources are added; the only change is improvement based on the learning curve.

In support of these assumptions, the following diagram indicates the cumulative retrofit capacity for industry's model (based on The Brattle Group report), as well as FRA's model. Based on these assumptions, the FRA model indicates that a heavy retrofit capacity exceeding the industry's projection is achievable.

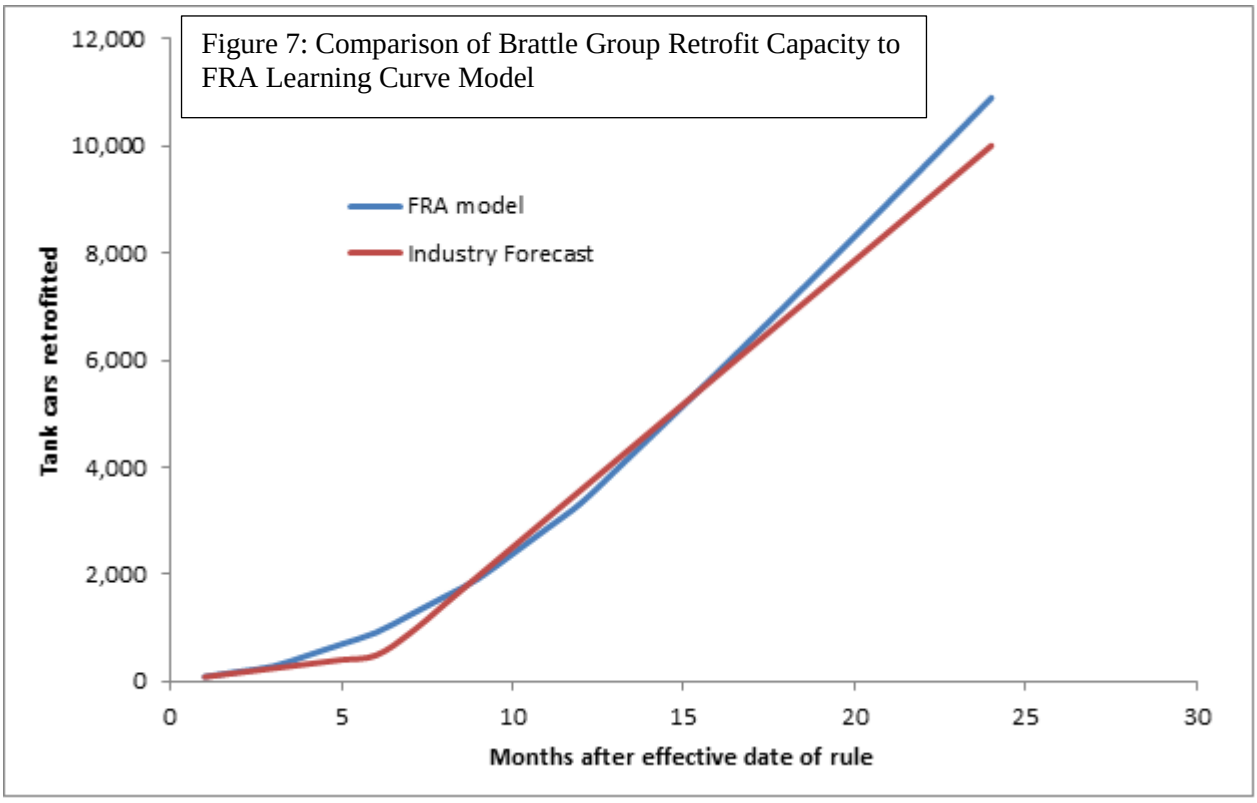


Figure 7: Comparison of Brattle Group Retrofit Capacity to FRA Learning Curve Model

Incorporation of the FRA learning curve into the PHMSA's fleet forecast results in a 22-month total heavy retrofit timeline. The retrofit timeline is provided in Table C2.

Table C2: Timeline for Continued Use of DOT-111 Tank Cars for Use in North America HHFTs			
Tank Car Type / Service	**Fleet Size**	**Canada Schedule**	**DOT Revised Schedule**
Non Jacketed DOT-111 tank cars in PG I service	11,637	May 1, 2017	**(January 1, 2017)**[55] **January 1, 2018**
Jacketed DOT-111 tank cars in PG I	2,268	December 1, 2020	**March 1, 2018**
Non Jacketed CPC-1232 tank cars in PG I service	15,144	July 1, 2023	**April 1, 2020**
Non Jacketed DOT-111 tank cars in PG II service	18,493	December 1, 2020	**May 1, 2023**
Jacketed DOT-111 tank cars in PG II service	88	December 1, 2020	**May 1, 2023**
Non Jacketed CPC-1232 tank cars in PG II service	751	July 1, 2023	**July 1, 2023**
Jacketed CPC-1232 tank cars in PG I and PG II service* and all remaining tank cars carrying PG III materials in an HHFT (pressure relief valve and valve handles).	24,993	May 1, 2025	**May 1, 2025**

Based on the FRA Model, the North American retrofit capacity will continue to grow to over 64,000 total heavy retrofits by June of 2023. Table C3 provides the number of heavy retrofits per year.

Table C3: Heavy Retrofits Per Year	
Year	**Retrofits**
2015	1,918
2016	7,037
2017	7,939
2018	8,236
2019	8,444
2020	8,606
2021	8,739
2022	8,852
2023	4,180

[55] The December 2016 date would trigger a reporting requirement, and shippers would have to report to DOT the number of tank cars that they own or lease that have been retrofitted, and the number that have not yet been retrofitted. December 2017 would still be the hard deadline for all shippers to use retrofitted legacy 111s in PG I service.

PHMSA and FRA reviewed comments, alternative timelines, and data regarding an appropriate retrofit timeline and revised our implementation schedule accordingly. As a result of this analysis, we have adjusted our proposal to more closely align with industry estimates for the retrofit capacity. With these changes, PHMSA is confident that retrofits can be accomplished within the parameters of the timeline adopted in the final rule.

C. Summary of Derailment Modeling

In the sections that follow, this document provides a discussion of the comments received in response to the derailment modeling performed during the NPRM stage of this proceeding. The section following the comment discussion provides a detailed description of the derailment modeling performed during the final rule stage of this proceeding. This section briefly introduces the derailment modeling conducted during the NPRM and final rule stages. The intent is to provide the reader with context and a basic understanding of the initial and final derailment modeling.

1. Summary of Derailment Modeling Performed for the NPRM

In support of the NPRM, two detailed technical supplements were developed and placed in the rulemaking docket:

1) Effectiveness Rates for Tank Car Options, and
2) Effectiveness Rates for Emergency Brake Signal Propagation Systems.

The technical supplements are summarized below.

Effectiveness Rates for Tank Car Options

This document was developed during the NPRM stage to describe the methodology used to calculate the effectiveness rates of alternative standards for tank cars to be used in HHFTs. In the NPRM, PHMSA considered three tank car Options, which incorporated design enhancements to protect the shell and heads of tank car tanks from puncture, protect the top and bottom fittings from damage, and to protect the tank from thermal tears or ruptures when exposed to pool fire conditions. The methodology described in this technical supplement relies on accident data to calculate the effectiveness rates for the entire design as well as individual design enhancement features. The calculated aggregate effectiveness rates and marginal design feature effectiveness rates, for the three proposed tank car Options are provided in the following Table C5.

Table C5: NPRM Tank Car Effectiveness Rates[56]						
Tank Car	**Total**	**Head Puncture**	**Shell Puncture**	**Thermal Damage**	**Top Fittings**	**BOV**
Option 1	54	21	17	12	4	<1
Option 2	51.3	21	17	12	1.3	<1
Option 3	41.3	19	9	12	1.3	<1

Effectiveness Rates for Emergency Brake Signal Propagation Systems

This document was developed to describe the methodology used to determine the effectiveness rates for advanced braking systems proposed for use on tank cars to be used HHFTs. In the NPRM, PHMSA considered four brake signal propagation systems: electronically controlled pneumatic (ECP) brakes, Distributed Power (DP), two way end of train devices (TWEOT), and conventional brake systems. The methodology described in this technical supplement relies on recent research that quantifies effectiveness based on number of cars punctured in a derailment. The inputs to this model included initial speed, tank car specification, and brake signal propagation systems. Holding the first two variables constant enabled the calculation of the effectiveness rate on the third variable, namely, the brake system. Modeling was performed for only one of the brake signal propagation systems so a methodology for estimating the effectiveness of the other brakes systems was developed based on the (train) energy dissipation during emergency brake application conditions. Relative to the conventional brake systems ECP was calculated to have a 36 percent effectiveness rate and EOT, DP and DP (2/3) an 18 percent effectiveness rate.

2. Summary of Derailment Modeling Performed for the Final Rule

In support of the HHFT final rule and this RIA, FRA and PHMSA contracted with Sharma & Associates, Inc. (Sharma) to develop an objective, engineering-based methodology to quantify and characterize the safety benefits and risk reduction or reductions in puncture probabilities, in hazmat rail transportation resulting from the implementation of mitigating strategies, such as improvements in tank car design or revisions to train operating practices (more detailed discussion of benefits is provided in Section VII). The simulations were performed using the Train Energy & Dynamics Simulator (TEDS) program, developed by Sharma to study the dynamics and energy levels under a variety of operating conditions. Sharma relied on TEDS to simulate derailments based on sixteen derailments listed in Appendix B.

[56] These effectiveness rates are measured relative to unjacketed DOT-111 railcars. Modelling and changes to the tank car options since the NPRM has made these obsolete.

The tank car community has focused on improving the derailment/puncture performance of tank cars over the past several years, especially given the recent accident history associated with hazardous material transport. Since the shipment by rail of hazardous material has increased, particularly crude oil, the focus on safety improvements, either through changes in tank car design or train operations, has also increased. In addition to this immediate and current focus on safety improvements, the tank car community has a need for an objective methodology to quantify and characterize the safety/risk benefits of future engineering changes and to use the resultant information to predict the performance of future designs.

As the tank car community reviews potential mitigating strategies/solutions for implementation, it becomes critical to have an objective measure of the expected improvements (i.e., reductions in risk or probability of puncture) that these solutions afford. While the industry has made progress on analytical techniques for quantifying puncture resistance for specific designs and specific impactor sizes, objective mechanisms to translate these analyses into overall safety improvements do not currently exist.

Tank cars are exposed to a wide range of hazards during operations or a derailment. These hazards come in the form of different impactor sizes, shapes, speeds, etc., making it difficult to quantify objectively, the overall safety improvement from any given change. For example, tank shell thickness increases may offer improvements against certain impactors, but not against others. In order to objectively compare the overall effectiveness of a proposed mitigating strategy/solution, whether it is a thickness increase or an operational change, regulatory and standards organizations must be able to understand and quantify the expected safety benefits resulting from the design changes or operational changes under consideration. Regulatory and standards organizations need a measure of how the solution is expected to perform in real life, against a variety of potential hazards. These organizations need to be able to answer questions such as:

1) What is the overall reduction in risk (or reduction in the probability of puncture) afforded by increasing the minimum required shell thickness to X inches?
2) What is the overall reduction in risk (or reduction in the probability of puncture) afforded by making a given operational change/restriction?

The industry's approach to answering this question has been to rely on past statistical data. RA-05-02, a report published by industry, has been used by AAR and other industry partners as a means to answer the above questions as it relates to thickness changes. This approach has several shortcomings, such as:

1) **Limited applicability** – This approach cannot be applied to innovative designs or alternate operating conditions;
2) **Inconsistency** – Risk numbers seem to change with the version of the data/model being used; and
3) **Limited dataset** – Using a limited dataset may not provide an accurate representation of all potential hazards, particularly low probability-high consequence hazards, and car designs/features present only in limited quantities in the general population of tank cars.

Therefore, there is a distinct need to develop an objective, analytical approach to evaluate the overall safety performance and the relative risk reduction resulting from changes to tank car design or railroad operating practices.

By working with Sharma, FRA and PHMSA have developed a model that ties together the load environment under impact conditions, with analytical/test based measures of tank car puncture resistance capacity and adjustments for suitable operating conditions, to calculate the resultant puncture probabilities and risk reduction. Specifically, we have provided an objective methodology for quantifying the safety performance (risk reduction) through the following approach:

1) Developing a consistent measure of the load environment associated with nominal tank car derailments through detailed analytical simulations.
2) Quantifying the puncture resistance of the given tank car designs for a nominal range of impactor sizes and impact forces, either through review of past published research (for conventional cars) or the development of new models (for innovative designs).
3) Adapting the load environment for changes in operating conditions and combining the load environment and the resistance curves with nominal impactor size distributions to evaluate the safety performance or probability of puncture for a set of designs and operating conditions.
4) Confirming the performance of the methodology through review of engineering expectations and comparisons to historical data.

D. Tank Car Performance Simulation Comments

Many commenters who provided data and analysis to refute PHMSA and FRA modeling data did so using Conditional Probability of Release (CPR) modeling. In addition, some commenters challenged PHMSA and FRA modeling as a point of weakness in our analysis. In July 2014, FRA released a study conducted by Sharma entitled "Objective Evaluation of Risk Reduction from Tank Car Design & Operations Improvements" that describes a novel and objective methodology for quantifying and characterizing the reductions in risk (or reductions in puncture probabilities) that resulted from changes to tank car designs or the tank car operating environment. This approach can be used as an alternative to CPR when describing tank car performance. The report is placed in the docket for this proceeding, see PHMSA-2012-0082-0209, and can be accessed online at www.regulations.gov.

The research effort described here addresses this need through a methodology that ties together the load environment under impact conditions with analytical/test-based measures of tank car puncture resistance capacity, which were further adapted for expected operating conditions, in order to calculate the resultant puncture probabilities and risk reduction. While not intended to predict the precise results of a given accident, this methodology provides a basis for comparing the relative benefits or risk reduction resulting from various mitigation strategies.

In addition, some commenters challenged PHMSA and FRA modeling as a weakness in our analysis. For example, Dr. Steven Kirkpatrick of Applied Research Associates, Inc. (ARA), in his September 29, 2014 comments to the NPRM, entitled *Review of Analyses Supporting the Pipeline and Hazardous Materials Safety Administration HM-251 Notice of Proposed*

Rulemaking, Technical Report, challenged the methodology used in the July 2014 Sharma & Associates study. These comments were combined with the AAR and its Transportation Technology Center, Inc. (TTCI) comments under docket reference number PHMSA-2012-0082-3378 of this proceeding. Sharma has worked to provide additional analysis and rationale to address the issues raised in the comments submitted by AAR and ARA. The issues raised and the responses are provided below.

1. ECP Kinetic Energy Effectiveness

Commenters indicate that Sharma's estimated reduction in kinetic energy, upon which PHMSA bases its premise of the effectiveness of ECP brakes, is based on a very limited set of simulations and looks only at derailments that occur at the head end of a train. Sharma has addressed this comment by replacing the data used for the ECP benefits simulation during the NPRM stage of this proceeding with results that more clearly address the specific provisions adopted in the final rule.

2. Length-of-Train Bias

Commenters indicate that another concern regarding the Sharma analysis is the bias resulting from limiting the analysis to trains with 80 cars. The result is likely a bias that overestimates the effect of ECP brakes. When conventional brake systems are used, the longer the train the longer the period for all the train brakes to be applied. Additionally, the deceleration effects of other cars blocking the motion of a car and the ground will be comparatively less for a longer string of cars since the residual mass behind the point of derailment will be larger.

During the NPRM, Sharma worked to identify the worst-case scenario in order to determine the scope available for improvement. In support of the final rule, additional simulations have been performed that include additional derailment simulations. Previously, 12 scenarios were used for each calculated most probable number of cars punctured. The scenarios have been expanded to 18, based on three track stiffness values, three friction coefficients, and two derailment-initiating force values. Additionally, derailment scenarios at different locations throughout the train were performed and the benefits calculations included for this variety of scenarios.

3. TTCI Train Operations and Energy Simulator (TOES) VS. TEDS

Commenters indicate that TTCI's methodology uses output from TOES to model the contribution of the braking system and other forces acting on the train in dissipating the energy in the train. According to comments, TTCI's analysis considered a number of factors that do not appear to be analyzed by PHMSA or Sharma, including:

- *Coefficient of Friction:* Commenters indicates that Sharma does not adequately take friction provided by the ground into account. Indicating that, Sharma uses coefficients of friction between 0.27 and 0.33. ARA contends that those coefficients are far too low and differ from previously published work, including research conducted by DOT's Volpe Center.

The friction factors used in Sharma's analysis are consistent with the friction levels that may be expected between soil and steel. For example, the friction factor between steel and "clean sand, silty sand-gravel mixture, single size hard rock fill" is reported as 0.30[57] with other factors varying between 0.2 and 0.4. Further, the suggestion of using a friction factor of 1.0 does not seem realistic. This value is close to the value of friction between rubber and concrete/asphalt, not soil and steel. As an example, modern high-performance sport cars are able to generate such high friction levels when equipped with specialized performance tires. One does not expect a tank car rolling down an embankment to have the same levels of friction or grip as a Corvette going around a racetrack. Additionally, a friction level of 1.0 would result in a car traveling at 50 mph to decelerate to a stop in 84 feet or about 1.5 car lengths. There is very little evidence of 50-mph derailments coming to a stop within 1.5 car lengths.

The range of friction factors used in Sharma's analysis is reasonable and representative of the relative performance of car designs.

- *Derailment Location in Train:* Commenters raise concerns that the Sharma analysis focused on derailments at the head end of an 80 or 100 car train. Commenters indicate that FRA data shows that the point of derailment is in the first 10 positions of the train in only 25 percent of derailments; in the remaining 75 percent of derailments the point of derailment is distributed evenly throughout the remainder of the train. The commenters indicate that the benefit will vary depending on the point of derailment in the train, which means that derailments that occur at various points in the train must be considered in order to assess the potential benefit of alternate braking systems. Modeling only derailments that occur near the front of the train overstates the effects of brakes on derailment severity, thereby overestimating the effect of ECP brakes.

  Simulations were performed in which the point of derailment (POD) along the train length has effectively, 100, 50, or 20 trailing tank cars. These simulations have been used by the DOT to effectively evaluate the relative performance of designs or operating conditions. It is also key to point out that the base case being considered (two-way EOT) is significantly more susceptible to overestimation of performance than ECP brakes. On a 100-car train, for example, the benefits of two-way EOT devices diminishes rapidly from the POD being at the head end to zero for the POD being at mid-point. For any derailment that happens in the rear half of the train, a two-way EOT train has no performance benefit over a conventional train.

- *Consideration of Non-pileup Derailments:* Commenters raise the concern that the effect of a braking system on derailments in which a pileup does not occur is more difficult to

[57] http://www.finesoftware.eu/help/geo5/en/table-of-ultimate-friction-factors-for-dissimilar-materials-01/

quantify, but should be recognized in an assessment of the potential reduction in accident severity because non-pileup derailments typically release less hazmat. We have considered all the derailments in Appendix B, which include both pile up and non-pile up accidents. Accordingly the full range of derailments outcomes is accounted for in our analysis.

This rulemaking is focused on derailment mitigation and prevention. For mitigation, the intent of the final rule is to reduce the impacts of rail accidents, but we are primarily concerned with those derailments in which large amounts of hazmat are released causing extensive damage and disruption. In regard to accident prevention, we agree with the commenters. Braking systems reduce kinetic energy and therefore help prevent and mitigate the effects of train accidents. FRA has conducted research on the effectiveness of advanced braking systems, which provide improved brake signal propagation time. PHMSA and FRA use that research to establish the need for advanced braking systems requirements. We discuss the derailment prevention aspects of advanced braking systems in the Braking Alternatives section of this RIA.

- *TOES Verification Using Event Recorder Aliceville, Brainard, and Wegnere*: The comments indicate the TTCI model concludes that if ECP brakes had been used in Aliceville, the energy in the derailment would have been reduced by only 12 percent, as compared to the distributed power that was actually used on that train. The model predicts that only 1.5 fewer cars would have reached the point of derailment with ECP brakes.

  The TTCI results are from stopping distance simulations while the FRA results are from derailment simulations. The TTC report does not simulate what happens in a derailment. The model developed by Sharma captures the following three elements of a derailment:

  1) stopping distance
  2) energy
  3) reduced chaos

  The Sharma model does include blockage force. All forces between all cars are calculated by the model and informed the development of the force histogram in the Letter report. The TTC report artificially introduces a blockage force because it does not model a derailment.

  Assuming AAR methodology is acceptable, 1.5 fewer cars reaching POD is a significant portion (8 percent) of the cars reaching POD. Further, in reviewing the comments provided by AAR, FRA concludes that calculation of "energy dissipated in derailment," provided in the comments, is three orders of magnitude too low. Also, the energy dissipated by the blockage force does not appear to be factored into the AAR calculation. These adjustments will affect the AAR results.

In the NPRM, PHMSA and FRA provided data produced by Sharma & Associates showing a 36 percent effectiveness rate of ECP brakes over conventional air brakes as expressed in number of cars punctured. In March 2015, Sharma & Associates finalized additional modeling that takes into account the comments received after publication of the NPRM. A comprehensive discussion of effectiveness rates is provided in Sharma's full report, entitled *Objective Evaluation of Risk Reduction from Tank Car Design & Operations Improvements – Extended Study*. The report is available in the public docket for this proceeding (PHMSA-2012-0082). The report indicates that ECP brakes result in substantially greater reductions in kinetic energy than EOT or DP brake systems. Specifically, 25.2 percent fewer tank cars would puncture if a derailment occurs at 40 mph, involving a train set with ECP brakes relative to a train set operating with a two-way-EOT or DP in the rear.

- *Variables and number of simulations run*: In its comments AAR indicates that TTCI conducted 420 simulations to compare the average percent reduction in energy and the average reduction in the number of derailed tank cars with ECP and conventional braking. According to AAR's comments, TTCI made the following assumptions:

  1) *Train speed at derailment* – speeds of 30, 35, 40, 45, and 50 mph were included.

  2) *Point of derailment within the train* – derailments occurring at the head-end, 1/4-way through the train, 1/2-way through the train, and 3/4-way through the train were included.

  3) *Track grade* – grades of 1 percent uphill, 1 percent downhill and flat (0 percent) were included.

  4) *Brake system* – conventional (head-end), conventional with end-of-train device (ETD), rear-end distributed power (DP), mid-train DP with ETD, DP at 2/3 with ETD, ECP, and ECP with rear-end wired DP were included.

  As a result of the simulations, the TTCI study estimates that ECP brakes will reduce the number of derailed cars by fewer than two cars, on average, compared to other braking systems. Further, according to TTCI, its analysis investigates only derailments that result in a significant blockage at the point of derailment and, therefore, likely overestimates the overall potential benefit, considering other types of derailments.

  The methodology used to support this rulemaking (with Dyna simulations) captures more of the derailment dynamics and puncture probability than a model such as TOES (or TEDS). TEDS kinetic energy analyses were intended as a preliminary study to determine the possible scope for damage reduction with alternate braking systems. Again, the methodology presented by AAR only captures the kinetic energy effects, not the subsequent derailment dynamics or puncture probability. Therefore, FRA contends that the TTCI study only captures a part of the benefit of ECP. Also, as pointed out earlier, the AAR predictions of two-way EOT or DP performance are overestimated, as such benefits are reduced to zero in the second half of the train, and drop steadily from the amount reported at the head end to zero at mid-point.

Commenters indicate that the Sharma analysis has erroneously assumed a linear relationship between the ratio of head puncture velocity and shell puncture force parameters and the probability of an accident-caused release. Commenters indicate that a linear relationship would only be true if the distribution of the impact force were uniform, which DOT's own analysis shows is not the case. Therefore, commenters state that PHMSA has overestimated the expected number of cars releasing for a given speed based on the following:

- *Impact Forces*: Commenters indicate that the approach seems to assume that the quantity lost in a derailment is solely a factor of train speed and not the mobility of the impactor.

  DOT recognizes that this simplification ignores some common modes of tank dynamics (rolling) and energy absorption (override); there are, however, sufficient features represented in the gross motions of the tanks, couplers and draft gears interacting with each other, the track and the ground that the methodology can be used for a first-order estimation of the relative benefits derived from various mitigation strategies.

- *Compression of Lading*: ARA indicates that the incompressibility of liquid lading is not accounted for in the analysis. AAR indicates that the result of modeling empty cars is to omit the high loads that occur when a loaded tank deforms enough to go shell-full and experiences a spike in both internal pressure and impact forces. Further, AAR indicates, as a consequence, the calculated collision force distribution will be incorrect in the analyses. In particular, AAR is concerned that the distribution would be skewed toward lower force levels.

  The intent of the DOT approach was to estimate relative merit of different designs. To that intent, modeling differences such as the one mentioned above are likely to make little difference. DOT is however in the process of evaluating this for a couple of test cases.

  To investigate the effect of internal pressure on the prediction of puncture risk, a set of derailment simulations was performed with a constant 75 psi internal pressure in the tanks, and the puncture risk was compared to a similar set of simulations without internal pressure. Internal pressure was simulated for a full set of 18 simulations for the 40-mph derailment speed, with 50 cars behind the POD. As expected, the predicted number of punctures was, on average, about 22% higher with the internal pressure than without, noting however, that this is a likely an upper bound. However, the relative improvement in puncture performance due to the various tank construction designs was almost identical to that predicted by the runs without internal pressure. The differences in relative puncture performance were only about 1.4% on average, reiterating the principle that minor differences in the modeling approach would make little difference when comparing the relative performance of designs.

- *Distribution of Impactor Size*: Commenters indicate that impactor size distribution is not well validated and engineering judgment suggests that a higher percentage of large impactors should be included, such as tank heads and shells.

The assumed impactor distribution includes a large number of impactor sizes approximating those of couplers and broken rails, and is therefore conservative regarding the probability of puncture. Multiple analyses have been run in which the impactor distribution was varied towards either larger or smaller impactors. It is clear from the results that even within that range of variations, the relative merits of a given design or operating condition are being predicted correctly.

- *Model Verification Method:* Commenters take note that Sharma attempts to validate its simulation model primarily by comparing the model's outputs – i.e., the number of cars derailed per train and the number of cars punctured or releasing product, all as functions of train speed – with the equivalent numbers from twelve actual accidents that occurred in the period 2002-2012. Commenters indicate that the validation is not adequate and should focus on the full range of FRA derailment data. AAR indicates that it cannot replicate Sharma's derailment data from FRA's database.

  FRA derailment database was intentionally filtered for incidents similar to the specific type of derailment simulated in Dyna. For the purpose of validating the Dyna model, only derailments within the intended domain of the simulation were included, such as derailments (not collisions) of freight trains, of a minimum length, on a mainline track, etc. (specific parameter values used for this filtering can be supplied). The Dyna model was intended to simulate the type of tank car unit train derailment leading to hazmat release with the potential for significant damage, not the full range of incidents reported in the FRA database.

  Derailments are highly individual and chaotic events. The intent of the model is not to replicate or predict any specific derailment, but rather to present a methodology that can be used to evaluate the relative merit of various potential strategies for mitigating damage in hazmat derailments. In addition, no attempt was made to characterize or correlate the FRA derailment data; the SA model results are simply presented with the applicably selected FRA derailment data to demonstrate that the model's results are appropriate and reasonable.

VII. Estimation of Expected Benefits

In this section we first describe the methodology and assumptions used by PHMSA for the initial RIA that accompanied the NPRM. We discuss the comments received, and how PHMSA responded to commenters and other additional information in formulating the final analysis.

A. NPRM Analysis

1. Summary of NPRM Benefits

The benefits of the proposed requirements included averted damages from higher consequence events and lower consequence events. The methodology used to calculate the expected pool of damages that could be reduced by promulgating regulations is documented in this section.

Estimated damages resulting from crude and ethanol incidents consist of two elements:

(1) An estimation of the number of HHFT accidents involving flammable liquids in absence of the NPRM and an estimation of the expected damages from accidents extrapolated from the existing U.S. hazardous materials accident records (we term these "lower-consequence events" or LCE); and
(2) An estimation of how many higher-consequence events might occur in absence of the NPRM and an estimation of expected damages from those higher-consequence events (the additional "higher-consequence events" or HCE range of estimates).

PHMSA monetized damages for LCEs based on the amount of product spilled. Damages may vary independently of the quantity released to some extent, but the severity of an incident is likely to be related to the quantity released. We used the known incidents in the U.S. safety record to calculate an average amount of quantity of product released. While we considered a number of data sources on the reported costs of those spills, but due to data quality concerns we used a cost estimate from the Lynchburg, VA accident. We used an estimated trend based on derailments per million carloads of product shipped to forecast the number of incidents that might occur over the analysis period, and monetize these events using the average quantity released and cost per gallon of product lost to estimate the damages from these incidents.

Probability of Major Rail Accident Based on U.S. Safety Record

PHMSA used the following methodology to estimate the probability of a major train accident involving multiple tank cars carrying flammable liquids.

To estimate the number of derailments associated with the movement of flammable liquids, we used FRA's Incident Database and the Surface Transportation Board (STB) Public Waybill Sample to develop an 19-year historical series (1995 – 2013) on annual derailments per million rail carloads, across all commodities.[58,59]

The STB collects cargo waybill data under the requirement that all U.S. railroads that terminate more than 4,500 revenue carloads submit a yearly sample of terminated waybills. This information provides an indication of the volume of freight rail traffic.

We combined these data that obtained through rail accident and incident reports submitted to FRA on from Form FRA F 6180.54, "Rail Equipment Accident/Incident Report" to estimate

[58] http://safetydata.fra.dot.gov/officeofsafety/publicsite/Query/incrpt.aspx

[59] http://www.stb.dot.gov/stb/industry/econ_waybill.html

historical derailment rates. Rail carriers are required to report accidents that occur on the following types of track: main, yard, siding and industry.

For the NPRM analysis, we developed a forecast based on incidents on all types of track. We then used the 18-year historical average (1995 – 2013) for incidents that occurred on mainline and siding track, and multiplied the predicted number of all future incidents by this percentage to isolate derailments that occurred on mainline and siding track only. PHMSA examined only derailments that occurred on mainline and siding track because we believe that the proposed rule will do little to mitigate the derailments that occurred in rail yards. Derailments in yards generally occur at such low speeds that the legacy DOT-111 would survive them, hence the enhancements being considered here would do little, if anything, to further mitigate release of hazardous materials during yard derailments.[60]

2. Other NPRM Analysis

Due to limitations in reported data, PHMSA used the derailment rate of all hazardous materials trains. The analysis was based on carload data, which does not account for distance travelled per train. We use a 19-year time period to obtain the largest possible sample size; Public Waybill Sample data is not readily available by carload prior to 1995.

PHMSA used the trend in this series to extrapolate to the number of derailments per million carloads throughout the forecast horizon (2013 – 2034) using the equation:

$$\text{Derailments per million carloads} = -1.2521 * \text{year} + 2564.5$$

This equation was based on historical derailments for all commodities because neither PHMSA nor FRA databases capture all derailments of all trains carrying crude and ethanol. PHMSA requires an incident report to be filed if a hazardous material is released, so derailments that do not result in a release are generally not represented in the PHMSA database. FRA's derailment database lists whether a derailed train was carrying any quantity of hazardous material, whether or not material released, but does not provide the type of hazardous material present on the train. As a result, it is impossible to use FRA data to identify crude and ethanol derailments. We experimented with other functional forms but none fit the data better than the linear trend and all produced nearly identical predictions, so we used the linear trend for simplicity. The original table from the NPRM displaying carloads, derailments, and derailments per million carloads from 1995 to 2012 is shown below.

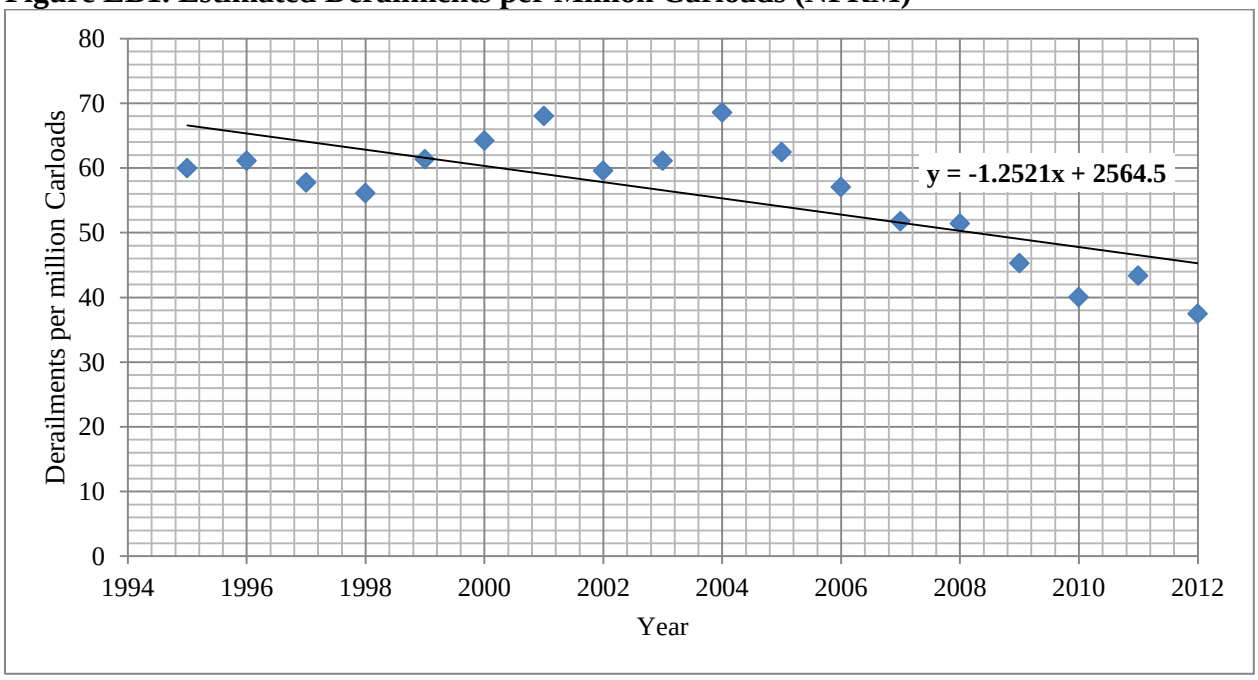
[60] For the purposes of the HMR, the term *movement* is defined in 49 CFR § 171.8.

Table EB1. Carloads Shipped and Derailment Rates, All Commodities, as Estimated in NPRM			
Year	**Carloads**	**Derailments**	**Derailments per Million Carloads**
1995	29,045,247	1,742	59.98
1996	29,723,309	1,816	61.10
1997	30,136,925	1,741	57.77
1998	31,311,638	1,757	56.11
1999	31,966,252	1,961	61.35
2000	32,890,352	2,112	64.21
2001	32,832,391	2,234	68.04
2002	33,385,605	1,989	59.58
2003	34,912,071	2,133	61.10
2004	35,495,079	2,435	68.60
2005	36,897,468	2,305	62.47
2006	38,499,461	2,197	57.07
2007	37,371,510	1,934	51.75
2008	34,817,858	1,790	51.41
2009	30,253,710	1,370	45.28
2010	33,328,373	1,335	40.06
2011	33,845,323	1,468	43.37
2012	34,377,852	1,288	37.47
Source: STB Waybill sample *http://www.stb.dot.gov/stb/industry/econ_waybill.html and PHMSA calculations.*			

PHMSA estimated this trend using data for all derailments (e.g., both yard movement and mainline derailments). As previously noted, commenters reported that mainline derailments have declined at a sharper rate than all derailments over the past 20 years. However, the estimates that result from using the mainline derailment trend alone to project future derailment rates did not seem credible to subject matter experts, because that trend would forecast derailments of crude and ethanol trains to fall to essentially zero by 2026. Subject matter experts contend that, generally, mainline track and car maintenance tend to be related to the total volume of rail shipments, and the recession that started in 2007 may have influencing the mainline derailment trend. Higher volume often means more volume of traffic on rail lines between maintenance, as well as higher car utilization rates, which also results in more ton miles per car between maintenance. As a result, volume affects derailment rates. Rail freight volumes declined significantly in 2008 and had yet to rebound to pre-recession levels by 2012. Concern that the recession may be influencing the steepness of the trend led PHMSA to use a trend based on all derailments.

The trend we estimated results in a 141 percent increase in volume shipped per derailment (total predicted carloads shipped divided by predicted derailments) for crude and ethanol shipment from 2014 to 2034. Looking at mainline derailments for all commodities, the number of carloads shipped per derailment increased by 138 percent from 1995 through 2012.

Figure EB1. Estimated Derailments per Million Carloads (NPRM)



Source: STB Waybill Sample and FRA Office of Safety Analysis

Estimating Mainline Derailments

To predict the expected number of future HHFT mainline derailments in the absence of the rule, we assume that the trends in derailments for crude oil and ethanol will be consistent with other commodities. Earlier, we projected derailment rates for all commodities, based on the trend equation computed above. PHMSA chose not to separate crude oil and ethanol into separate baselines because the materials present similar hazards and are transported in a similar way.

Next, we used 2014 EIA data on production to project future carloads of crude and ethanol.[61] We multiplied those projected derailment rates by the projected carloads to obtain the expected total annual derailments for crude and ethanol.

[61] Source of both crude and ethanol production forecast: Energy Information Administration's Annual Energy Outlook, 2014. Carloads forecast based on production by extrapolating a linear trend based on historic relationships between two series of numbers, and ethanol forecast using an estimated linear trend of historic ethanol carloads based on historic production. Formula for ethanol forecast was EIA ethanol production reference case*1.0476 – 8,814.

Finally, to project mainline derailment rates for crude and ethanol, we assumed that the share of derailments that occur on mainline track is the same for crude and ethanol as it is for all commodities. The FRA derailment data from 1995 to 2012 indicates that approximately 38.5 percent of derailments of all commodities occur on mainline track.[62] We applied these proportions to the predicted number of crude oil and ethanol derailments to estimate the number of future mainline derailments. This derailment forecast is presented in the table below.

Table EB2. NPRM Projected Carloads of Ethanol and Crude and Mainline Derailments (2015 – 2034)

Year	Carloads	Main Line Derailments
2015	898,500	14.36
2016	924,707	14.34
2017	937,808	14.09
2018	949,434	13.80
2019	962,470	13.53
2020	971,605	13.19
2021	969,195	12.69
2022	965,957	12.18
2023	956,047	11.60
2024	948,974	11.05
2025	934,230	10.43
2026	909,673	9.72
2027	892,919	9.11
2028	873,274	8.49
2029	851,981	7.87
2030	829,771	7.26
2031	810,028	6.70
2032	790,030	6.15
2033	772,230	5.64
2034	755,613	5.16
	2015 – 2034 Total:	207

Source STB Waybill Sample and FRA Office of Safety Analysis

There is reason to believe that derailments of HHFTs will continue to involve more cars than derailments of other types of trains. There are many unique features to the operation of unit trains to differentiate their risk. The trains are longer, heavier in total, more challenging to control, and can produce considerably higher buff and draft forces which affect train stability. In addition, these trains can be more challenging to slow down or stop, can be more prone to derailments when put in emergency braking, and the loaded tank cars are stiffer and do not react

[62] http://safetydata.fra.dot.gov

well to track warp which when combined with high buff/draft forces can increase the risk of derailments.

In response to the NPRM analysis, several commenters pointed out that derailments on mainline track have been declining at a faster rate than incidents in rail yards. Thus, using an overall 18-year historical percentage is a limited way to isolate the trend of derailments on main and siding track. For the final rule analysis, we have re-estimated the trend using the average number of annual derailments of crude oil and ethanol over the past five years.

B. Final Rule Analysis

1. Derailment Rate

For the estimation of benefits during the final rule stage, the PHMSA no longer uses the approach of estimating a derailment trend for all trains/carloads or any subset of carloads. Several industry commenters suggested that we should consider only crude and ethanol rail incidents rather than attempting to forecast them indirectly based on a trend that involves other commodities. In addition, the environmental groups commenting on the rule suggested that forecasting derailments involving crude and ethanol forward based on volume shipped was appropriate. The approach used for the final RIA is adjusted to accommodate these comments. Since data available from 2009 to 2013 shows industry is shipping high volumes of crude and ethanol by rail, the PHMSA takes the average number of mainline crude and ethanol derailments for the past 5 years (5.8 derailments), and divides that number by the average number of carloads of crude and ethanol shipped over those 5 years (545,322 carloads). This provides an annual derailment per carload estimate based on the most recent 5 years of data. Because we found derailment rates for crude and ethanol to be nearly constant over time, we have eliminated the declining trend used in the NPRM to predict future derailment rates. We then apply this constant rate per thousand carloads (0.010636) to the annual forecast thousands of carloads of crude and ethanol from 2015 to 2034 to obtain an estimate of the number of derailments that occur. This is a more straightforward approach and also focuses on known crude and ethanol derailments that is driven from recent industry data of carloads shipped and data collected on the number of derailments. PHMSA examined several other models for predicting crude and ethanol incidents which are presented in Appendix F of this document. The model the PHMSA considers most valid for forecasting crude and ethanol derailments, the Poisson regression model presented in Appendix F of this document, provides results that are fairly comparable to those produced using the rate based on the past 5 years of carloads and incidents.

PHMSA and FRA believe that a brief discussion of other recent regulatory actions on the projected derailment rates utilized in this analysis is worthwhile. As none of the recent regulatory actions were designed or intended to specifically address HHFT derailments, PHMSA and FRA do not believe any of the regulatory actions discussed below will significantly reduce the number of HHFT derailments targeted in this analysis. The standards contained in the recently issued Rail Integrity final rule promote the safety of railroad operations by establishing the rail flaw detection standards. This includes officially establishing minimum qualification requirements for rail flaw detection equipment operators and revising the existing requirements. These amendments require the railroads to determine rail inspection frequencies by utilizing a performance-based method. The bulk of the regulation revised FRA's Track Safety Standards by

codifying current industry good practices. In analyzing the economic impacts of the rule, FRA did not anticipate that any existing operation will be adversely affected by these changes, nor did FRA expect that the changes would induce any significant costs. Rather, FRA anticipated that this rulemaking would enhance the current Track Safety Standards by allocating more time to rail inspections, increasing the opportunity to detect more serious defects sooner, providing assurance that qualified operators are inspecting the rail, and causing inspection records to be updated with more useful information. However, the only benefit that was taken was a four hour window which allowed a railroad to finish an inspection sooner. There was no safety benefit taken in the RIA for this regulation, it was only a business benefit.

The recently issued RSIA-mandated Training Standards final rule is generally intended to improve safety on small railroads and their contractors (which may not have adequate training programs) and maintenance-of-way employees, who are not required to be certified and are often contractors. The Training Standards final rule will also address a potential issue that could arise from the changing demographics of the railroad workforce by helping to ensure new employees learn outside of the classroom environment through structured on-the-job training (OJT). The rule will not go into effect until 2018 for Class I railroads and 2019 for smaller railroads, and employees will need to go through the training in order for the rule to have a safety impact; therefore, we will likely not see an impact from this rule until 2020. Moreover, when we do see the impacts, it will likely be on maintenance-of-way and maintenance-of-equipment employee safety and on small railroads and their contractors. PHMSA and FRA believe that there will probably be minimal if any impact on bulk crude oil and ethanol transportation, as the employees involved in the movement, equipment maintenance, and track activities related to these commodities already receive and have received for years the types of training required under the regulations. PHMSA and FRA believe that the regulation will generally maintain current safety levels as we see greater levels of employee turnover in these types of operations. The analysis conducted in support of this rule was a break-even analysis, recognizing that FRA had no way of estimating its safety improvement. The reduction rates assumed in that analysis was intended to be a worst-case scenario for purposes of analyzing the safety risk available for the Training Standards rule to address (only for purposes of conducting a break-even analysis) and still be cost beneficial. Qualitatively, it seems highly unlikely that the Training Standards rule will have a measurable impact on the number of derailments of trains transporting crude oil or ethanol. The safety benefits that support the break-even conclusion are in part to prevent the expected increase in risk associated with generational turnover. The safety areas that are most likely to be affected are railroad employee safety and safety for small railroads and contractors.

The recently issued NPRM related to Risk Reduction Programs proposes to require Class I railroads and freight railroads with insufficient safety performance to develop risk reduction programs. The NPRM would require railroads to conduct hazard analyses to determine and prioritize areas of risk to address in order to achieve continuous safety improvement. Different railroads may have different safety issues that are unique in many respects to their operations. This will result in a tailored/custom approach versus a uniform set of hazards and mitigations across railroads. RSIA required that each risk reduction program have a fatigue mitigation plan and a technology implementation plan, so there will be improvements in these areas of safety across the board. Many Class I railroad crude oil routes would see safety improvements at some point. However, the timeframes and levels of improvement are uncertain because they depend on the operator's development and implementation of mitigations to address hazards unique to

its operation. Risk reduction programs may identify more effective ways of implementing the PHMSA rule, for instance, for the analysis and selection of crude oil routes. The economic analysis for this NPRM used a break-even approach due to the uncertainty regarding the type of accidents and incidents that will be prevented. The rule likely will not become final and in effect until 2016, and the plans would not be required until 2018 or 2019. The safety benefits that result will not be realized until the mitigations are put in place following the hazard assessments. In the meantime, there is a significant multiyear gap in safety. Some forms of mitigation may require significant lead times to implement and improve safety. Safety improvements resulting from the risk reduction rule would likely not be realized for a significant number of years and we do not know what areas of safety will be impacted or addressed during the early implementation of mitigation measures nor will the effects of any mitigation measure be readily known until after having been in place for a period of time. As HM-251 will be published and go into effect prior to the risk reduction program final rule, we would expect the benefits of any risk reduction regulation to account for the safety environment at the time of its publication.

A recent FRA final rule restricting railroad operating employees' use of cellular telephones and other distracting electronic devices followed a 2008 Emergency Order addressing the issue of electronic distraction of operating crews. The rule provides clear guidance on how and when electronic devices may be used during safety-sensitive activities, and prescribes penalties for those using electronic devices when such use is prohibited and could interfere with the performance of safety-sensitive activities. As this rule was implemented prior to the accident at Lac Mégantic, and before there was a major shift in our rail traffic to include a significant amount of oil, we do not believe that the benefit pool from this rule would have any overlap with the benefit pool being used in the current final rule. The majority of rail accidents that we are considering in this analysis involving crude and ethanol occurred after the issuance and implementation of the distracted driving EO and regulations.

PHMSA and FRA further believe that there is little overlap with respect to the accident pool addressed in the recent regulations related to the implementation of PTC systems and this current final rule. Meaning the crude oil accidents, which we reviewed for this final rule, would not have been PTC preventable. In addition, due to several technical and programmatic issues, the vast majority of PTC systems will not be implemented by the December 31, 2015 deadline. FRA's 2010 PTC final rule implied that roughly 44 accidents (not limited to overspeed derailments) per year would be prevented. As noted above, none of the accidents we observed for purposes of this final rule would have been PTC preventable. Overall, there is thus very little, if any, overlap between the prevention measures in the PHMSA rule and the accidents that PTC will prevent.

FRA's recently issued EO 28 requires railroads to review their existing securement protocols to ensure that they identify a sufficient number of handbrakes to be set when leaving trains unattended. Existing FRA regulations already contain specific securement requirements when equipment is left unattended. EO 28 adds to these existing requirements when equipment containing certain hazardous materials are left unattended on mainlines and sidings. PHMSA and FRA do not believe that EO 28 or the related securement NPRM will impact the derailment rates utilized in this final rule.

PHMSA also does not believe that the derailment rate used in the final analysis should be adjusted based on the operating requirements in this rule – such as the speed restrictions and routing requirements – or actions agreed to by railroads to increase track inspections and use routing technology to determine the safest and most secure routes.

In addition to revising the derailment forecast, PHMSA also revised the estimated number of affected carloads expected to be shipped over the analysis period. The original carload projection was based on the historic relationship between production and carloads shipped by rail. While ethanol has a reasonably long historic trend (dating back to 2005) to use for estimating the relationship between production and shipments by rail, the shipment of large quantities of crude oil by rail is a very recent phenomenon. It is obvious that a much larger quantity of crude oil is being shipped by rail relative to total production than has been shipped by rail in the past. Because the Agency's NPRM estimates were based on the historic data, they may have underestimated the total number of carloads expected to be shipped by rail.

For this final rule, PHMSA replaced its original forecast with the figures presented by RSI in their comments to the docket, specifically the figures in Exhibit B4: Crude and Ethanol Rail Traffic Summary in Appendix D of RSI's comments. RSI relied on the same EIA production forecast the Agency used to estimate carloads going forward. However, there has been a major and very recent shift in crude oil shipment patterns (starting in 2011 or 2012) resulting in a greater portion of crude oil being shipped by rail in the past 2-3 years than at any recent time in the nation's history. The short timeframe of high volume crude oil shipments by rail makes forecasting future demand for shipping this commodity by rail difficult. While the Agency attempted to make its forecast at the NPRM stage as accurate as possible, we believe that the RSI knows more about future crude oil shipping patterns, and hence can produce a more accurate forecast of the quantities of crude oil likely to be shipped over the next 20 years. This table provides projected rail carloads from 2014 through 2025 for the North American tank car fleet dedicated to crude and ethanol service. However, RSI's figures contain estimates of crude oil and ethanol rail traffic for the U.S. and Canada, combined. Since this Final Rule is being promulgated by the U.S. Government and is only binding upon U.S. citizens and entities, we must remove the shipments that originate and end in Canada to limit the safety benefit and cost analysis to those that occur in the U.S. Canadian carloads are removed via the following method:

- First, the Agency estimates domestic carloads of ethanol as it did at the NPRM stage. This trend tracks linearly with production and the Agency believes it is fairly accurate. These carloads are subtracted from the RSI carload forecast, leaving a forecast that includes domestic crude and Canadian crude and ethanol shipments.
- Next, reduce the remaining carloads (i.e., those containing domestic crude and Canadian crude and ethanol) by the percentage of the fleet owned and operated in the United States. According to the Canadian Government, their portion of the fleet makes up about 25.7 percent of the North American fleet. It seems reasonable to assume that cars would be

proportional to shipping demand, so we multiply the RSI carload forecast by 0.743 to obtain U.S. carloads of crude oil.

- Since the RSI forecast only goes through 2025, some method is required to project the forecast to 2034. We project forward from 2026 through 2034 based on the percent change in the EIA production forecast.[63]
- Once we have U.S. crude oil carloads, we add U.S. ethanol carloads to this figure to get the total estimated carloads for the two commodities.

The table below shows the total forecast U.S. carloads of crude and ethanol, and the total predicted mainline and siding derailments of crude and ethanol trains for 2015 to 2034. More carloads are forecast to be shipped for the Final Rule analysis than for the NPRM.

The forecast number of derailments was modified slightly to account for the number of higher consequence events. As described in the higher consequence event section we estimate that 2 such events may occur over the 20 year analysis period. As a result, we subtract 2 derailments from the LCE total. The implicit assumption is that the HCEs would be drawn from the pool of LCEs, and hence leaving them in the LCE pool would over-count societal damages and hence benefits. We subtract one derailment from the estimated number in each of the following two years: 2023 and 2027. PHMSA does not assume that HCEs will necessarily occur in these years.

Table EB3: Predicted Crude and Ethanol Derailments

Year	Thousands of Carloads of Crude and Ethanol	Predicted Crude and Ethanol Derailments	Derailment Rate (per thousand carloads)
2015	1119	11.90	0.010636
2016	1124	11.95	0.010636
2017	1164	12.38	0.010636
2018	1250	13.29	0.010636
2019	1327	14.11	0.010636
2020	1409	14.99	0.010636
2021	1416	15.07	0.010636
2022	1418	15.09	0.010636
2023	1418	14.08	0.010636
2024	1422	15.13	0.010636

[63] Source for crude oil production data: 2014 Annual Energy Outlook: http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=0-AEO2014&table=14-AEO2014&region=0-0&cases=ref2014-d102413a

2025	1418	15.09	0.010636
2026	1391	14.80	0.010636
2027	1369	13.56	0.010636
2028	1346	14.32	0.010636
2029	1322	14.06	0.010636
2030	1296	13.78	0.010636
2031	1273	13.54	0.010636
2032	1248	13.28	0.010636
2033	1227	13.05	0.010636
2034	1207	12.83	0.010636
	Total:	276.29	

Product Lost Per Derailment

PHMSA bases the costs associated with a derailment on the amount of product released when a derailment occurs. Because damages are higher for derailments on mainline track, these derailments are treated differently than those that occur in yards. In order to monetize mainline derailments it is necessary to determine the average amount of product lost.

PHMSA focused on derailments of crude oil and ethanol trains from 2006 through 2013. We focused on this date range because it encompasses the beginning of the shipment of flammable liquids in HHFTs. We chose to exclude 2014 because information for recent rail accidents may not be finalized. We include the preliminary figures inclusive of the nine rail accidents in 2014 in Appendix B for informational purposes.

PHMSA examined two separate incident-reporting databases to estimate the expected loss of product per derailment:

(1) The PHMSA Hazardous Materials Incident Report database; and
(2) FRA Railroad Safety Information System.

PHMSA collects information on incidents that result in the release of hazardous material in transportation including the type of hazardous material released, the mode of transport, and the number of packages releasing hazardous materials. The FRA collects information on derailments regardless of the commodity, the type of track (mainline, siding, industry), the number of cars derailed, the number of cars that release product and whether hazmat was involved. We combined the information from these two datasets to estimate the number of derailments of crude oil/ethanol cars on mainline and siding track.

PHMSA generally does not collect information on derailments unless the derailment results in the release of hazardous material, and FRA generally does not collect data on the specific hazmat commodity involved in a derailment. Due to each dataset's limitations of the information collected it is possible that some mainline derailments of crude oil/ethanol that did not result in a release of product were not examined.

For the period between 2006 to 2013, we identified 40 mainline derailments that resulted in the release of 3,344,081 gallons of crude oil and ethanol for an average of approximately 83,602 gallons released per mainline track derailment. These 40 mainline derailments are listed in Appendix B. Before beginning computation, we removed derailments that occurred in rail yards and removed incidents that were not the result of a derailment because these accidents are not the focus of the final rule and the provisions would do little to mitigate these accidents.64 In addition we corrected the data by comparing the PHMSA and FRA incident databases and detailed inspection reports when available.

Based on a review of the reported description of events and a comparison to the FRA incident database we identified the following crude oil/ethanol incidents that either occurred in a yard and are not subject to PHMSA reporting requirements or involved a release of ethanol or crude oil that was not a result of a derailment:

Missoula, MT: 6/18/2006	Harve, MT: 11/1/2010
Kansas City, KS: 12/1/2006	Roanoke, VA: 12/2/2010
Amarillo, TX: 12/25/2006	Jackson, NE: 3/17/2011
Los Angeles, CA 1/9/2007	Antelope, CA: 6/11/21011
Chicago, IL: 8/27/2007	Texas City, TX: 09/13/2011
La Mirada, CA: 4/9/2009	Hitchcock, TX: 09/13/2011
Martinez, CA: 4/13/2009	Stockton, CA: 6/27/2011
Rosemont, IL: 5/18/2009	Pasco, WA: 11/07/2011
Minneapolis, MN: 11/27/2009	Monroe, LA: 12/1/2011
Fresno, CA: 12/17/2009	Las Vegas, NV: 08/11/2012
Birmingham, AL: 2/18/2010	Knoxville, TN: 10/12/2012
	Tampa, FL: 07/25/2013

The PHMSA hazardous material incident report database often contains inaccuracies. The database presents information on releases of hazardous material in transportation and relies on the person in possession of the hazardous material at the time of the incident to report on the incident. Often the amount of product released from a particular tank car is unclear or reported differently in the description of events than in the appropriate incident report fields. Additionally, the PHMSA incident reports often do not reflect the full extent of damages including property damage, cleanup, and remediation costs because it may be months before full damage figures can be reported. By regulation the filer has a maximum of thirty days from the time of the incident to file a report. Even though the filer is responsible for updating or supplementing the initial report if additional information becomes available and has one year

[64] PHMSA reporting requirements only apply to mainline/siding track derailments. Nevertheless, some companies do report yard derailments. Further, this analysis focuses on the damages that result from a derailment, but some companies report releases that were not the result of a derailment.

from the date of the incident to do so, PHMSA do not always obtain full information. When we compared the incident report information from the PHMSA hazardous material incident report Database with data obtained through more thorough investigations, we discovered that the quantity of product lost and number of cars releasing product were misreported in a number of cases. Below are notable examples:

- Parker's Prairie, MN 3/27/2013: The reported release in the report DOT 5800 report field suggested that one car released 10,000 gallons while the description of events reported that four cars derailed and released 15,000 gallons. In this case PHMSA compared this information to the FRA incident database for the same incident. The FRA information confirmed that for this incident 14 cars derailed and 3 cars released approximately 15,000 gallons.

- Aliceville, AL 11/07/2013: The initial estimate of crude oil lost in the Aliceville, AL, derailment was 28,000 gallons. Based on a follow-up from PHMSA personnel, the carrier has since revised this estimate to more than 450,000 gallons.

- Philadelphia, PA 1/20/2014: A 101-car train was travelling from Chicago to Philadelphia derailed on a bridge. Seven cars derailed and six of the derailed cars were carrying crude oil. There was no reported release of the crude oil. This derailment was reported to the FRA, but since it did not result in a release of hazardous material, so it was not reported to PHMSA.

- New Augusta, MS 1/31/2014: The product contained in the incident cars was reported to PHMSA as NA1993 Combustible Liquid, n.o.s. (fuel oil). Information obtained by the FRA during a follow-up investigation revealed that the cars that derailed contained crude oil. Because this was reported to PHMSA as NA1993 and not UN1267, it would not be found using the search for crude oil or ethanol. Based on this additional information, this incident was added to the list of incidents suitable for inclusion. In this analysis, PHMSA elected to use FRA inspection reports that state that for this incident 13 cars derailed and 4 cars released approximately 90,000 gallons.

- Vandergrift, PA 2/13/2014: The incident involved a train carrying crude oil and liquefied petroleum gas. The description of events in the PHMSA incident report states that four cars released a total of 8,300 gallons of product. The report fields for that same report suggested that six cars released 9,800 gallons of product. In this analysis PHMSA elected to use FRA inspection data that says 21 cars derailed and 4 cars released a total of 10,000 gallons.

Monetizing Events Based on Quantity Released

Each incident involving a significant spill of crude or ethanol will have numerous types of costs. In addition to the costs of any injuries or fatalities, which are addressed in the following section, spills will involve cleanup costs. The spills may also involve property damage, costs for emergency response, evacuation costs for residents or workers in the surrounding areas, environmental damage, transportation delays while the spill is being cleaned up, as well as other

costs. As we discuss in the "Higher-Consequence Events" section below, the costs of a spill will depend on not only the size of a spill, but also where it occurs, the type of material spilled, and the circumstances of the accident. There is likely to be more property damage if a spill occurs in a densely populated area or if it results in a fire. There is likely to be more environmental damage if the spill occurs in an environmentally sensitive area. Costs of cleanup may be higher for heavier crude oil that does not burn.

PHMSA estimated the costs of released product by applying a monetary value to each gallon spilled. This implicitly assumes that costs per gallon are linear with (i.e., vary in direct proportion to) the volume of product spilled, but PHMSA intends the value to reflect an average, recognizing the number may be declining with respect to the volume spilled due to economies of scale in cleanup costs. To estimate the cost per gallon of crude or ethanol released, PHMSA examined news and railroad reports from two crude oil incidents for which cost estimates are at least preliminarily available, evaluated cost estimates prepared by the NTSB, reviewed cost estimates reported by railroads to PHMSA in hazardous material incident reports for both ethanol and crude oil, and consulted preliminary modeling by Dagmar Schmidt Etkin on the cost of responding to oil spills.

PHMSA conducted a review of the literature on crude oil and ethanol spill costs, available data from Federal Agency databases on hazardous liquid spill costs, and reports from rail carriers on individual spills, which substantiates an estimate of $200. The review found that damages could be as high as twice that amount for crude oil spills, and substantiates a cost for ethanol spills at $144 per gallon.

From the literature, the Agency derived a cost of $144 per gallon for ethanol spills (see reference in the appendix for Saat et al 2013). The Agency's HMIS database produces estimates of approximately $16 per gallon for both crude and ethanol incidents, but we have serious concerns about the quality of the data submitted to the HMIS database, and since most estimates for crude oil spills exceed $100 per gallon, there seems justifiable reason to be concerned. Much of the literature is focused on maritime spills and it is unclear how applicable those figures are to other modes. However, the few estimates from studies that do consider other modes produce averages that meet or exceed $200 or even $300. The Agency consulted its database on pipeline incidents as well, and has more faith in the quality of the cost data in that database than in the data on rail crude and ethanol incidents. The figures derived from the pipeline data are presented below. For 2011-2015 the cost per gallon for pipeline incidents (dividing total gallons spilled into total costs for all incidents over this time period) produced an estimated cost of $211 per gallon for crude oil incidents, and the estimate for the spill volume category that matches the average historical crude oil and ethanol derailment (50,000 – 99,999) is $368 per gallon.

Table EB4. Pipeline Spill Size and Cost of Spill

Spill size	Total Quantity released	Total Cost	Cost per Gallon
All	7,140,431.8	$1,508,025,860	$211
>100000	4,670,484.0	$1,050,258,418	$225
50000-99,999	474,348.0	$174,363,499	$368
10000-49999	1,309,299.6	$152,408,143	$116
1000-9999	576,685.2	$55,355,979	$96

Table EB4. Pipeline Spill Size and Cost of Spill			
Spill size	**Total Quantity released**	**Total Cost**	**Cost per Gallon**
500-999	51,483.6	$14,226,316	$276
100-499	42,594.3	$19,786,918	$465
50-99	7,447.0	$7,820,282	$1,050
5-49	8,043.0	$19,953,229	$2,481
<5	47.0	$13,853,076	$294,496

The Agency's carload forecast indicates that ethanol will make up approximately 32 percent of total carloads shipped over the next 20 years, and 68 percent of carloads shipped will be crude. Thus, a weighted average of the values for the two commodities produces an estimate of $211 × .68 + $144 × .32 = $190. Given that much of the literature suggests that the costs imposed on society by crude oil spills exceeds that derived from the pipeline data, we round this figure up to $200 per gallon.

The two crude oil incidents for which preliminary cost estimates have been made are the catastrophic incident at Lac-Mégantic, Quebec, and the recent derailment at Lynchburg, Virginia. We do not consider Lac-Mégantic in this estimate. An average based on Lac-Mégantic would not be representative of damages from a typical accident or even a high consequence accident that this rule is intended to mitigate (see Appendix C). The train involved in the Lynchburg incident originated in the Bakken shale region in North Dakota and consisted of two locomotives and 105 cars. On April 30, 2014, seventeen cars were derailed and two of them spilled crude oil in the James River. Approximately 350 residents were evacuated for approximately 3.5 hours.

The Lynchburg incident resulted in 30,000 gallons spilled. The emergency response and cleanup costs for that incident were reported to the FRA by CSX as $8.99 million. Of this $8.99 million cost, an estimated $5 million was due to environmental damage. The CSX estimate of the costs of Lynchburg results in a cost per gallon of crude of about $300.

Table EB5. Breakdown of Damages as a Result of the April 30, 2014 Derailment in Lynchburg, VA		
Description	**Number/Quantity**	**Costs ($ Million)**
Fatalities	None	0
Injuries	None	0
Track Damage		$0.25
Equipment Damage		$3.29
Environmental Damage	30,000 gallons	$5.00
Property Damage		$0.05
Evacuation	350 residents	$0.40
Highway Closure		0
Total Costs		$8.99
Source: CSX as reported to FRA		

PHMSA also examined NTSB reports of rail accidents, PHMSA's own hazardous materials incident report data, modeling done by the U.S. Coast Guard, and several other studies from the literature reviewed.

NTSB investigations of four ethanol and crude oil spills since 2006 are available. NTSB reports that the 2006 New Brighton incident released 485,278 gallons of ethanol and imposed estimated costs of $5.8 million, for a cost per gallon released of $12;[65] the 2009 Cherry Valley incident released 431,708 gallons of ethanol and imposed estimated costs of $7.9 million, for a cost per gallon released of $18;[66] the 2011 Tiskilwa incident released 259,000 gallons of ethanol and imposed estimated costs of $1.6 million, for a cost per gallon released of $6;[67] and the 2013 Casselton incident released 400,000 gallons of crude oil and imposed estimated costs of $6.1 million, for a cost per gallon released of $15.[68]

The NTSB data do not, in most cases, consider remediation and cleanup costs. In its Tiskilwa report, the NTSB's estimated damages represent only property damages. For Cherry Valley, damages seem to be limited to property damages, given where they are presented in the report (though NTSB does not specify). For New Brighton, the damages include $2.5 million that ostensibly accounts for lost product, emergency response, remediation, and incidentals—yet almost 500,000 gallons spilled. This estimate is not credible because the product alone was worth over $1 million. Although the source of the NTSB's damage estimate was the railroad involved, like the source of the Lynchburg damage estimate used in this NPRM, PHMSA does not believe that Norfolk Southern railroad accurately estimated costs in the case of New Brighton.

PHMSA's hazardous materials incident report data are based on incident reports submitted by the involved railroad within 30 days of the incident. Among other information, the railroad is required to report a narrative description of the event, the commodity released, the volume of product lost, and the costs of the incident, including material loss, carrier damage, property damage, response cost, and remediation cleanup cost. Railroads are required to update their initial report if the initial estimates prove inaccurate. Of the 40 mainline derailments involving crude oil and ethanol releases since 2006, hazardous materials incident report data indicate that a total of 3,344,081 gallons were released and total damages were $47,252,409, for an average cost per gallon released of $14.13. Ethanol derailments account for 32 of the 40 total derailments, and the quantity released in those derailments was 2,317,737 gallons, for an average of 72,429

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[65] http://www.ntsb.gov/doclib/reports/2008/RAR0802.pdf

[66] http://www.ntsb.gov/doclib/reports/2012/RAR1201.pdf

[67] http://www.ntsb.gov/doclib/reports/2013/RAB1302.pdf

[68] http://www.ntsb.gov/doclib/reports/2014/Casselton_ND_Preliminary.pdf

gallons released per derailment. Eight of the 40 derailments were crude oil derailments. In total, these derailments resulted in release of 1,026,344 gallons of crude oil for an average per derailment of 128,293.

PHMSA believes that in many cases the hazardous materials incident report data are also incorrect. Total damages from a narrative description of events often do not match the information provided in the corresponding report field. Additionally, damages and costs reported appear to be extremely low. A case in point is the Arcadia, Ohio (2/6/11) derailment (32 cars, the release of 786,245 gallons of ethanol and the evacuation of 25 people for 8 hours); the $187,410 damages reported for this incident is implausibly low. Damage information reported to PHMSA generally includes only the most basic costs such as the value of lost product and preliminary estimates of damages to rail cars or track. PHMSA believes that response costs and basic cleanup costs, when they are reported, do not represent the full costs of an accident or the response. Reports may exclude evacuation of the public, disposal of contaminated soil, air quality and site monitoring and other costs. While it is incumbent upon the person who reports a hazardous materials incident to supplement their initial report, this most often does not happen unless PHMSA follows up with the filer. For example, the initial estimate of crude oil lost in the Aliceville, AL, derailment was 28,000 gallons. Based on a follow-up from PHMSA personnel, the carrier has revised this estimate to more than 450,000 gallons. Beyond simple revisions in volume released, cleanup costs also tend to escalate after an initial report. PHMSA therefore expects costs reported to be biased downward.

Etkin presented preliminary results from a model she developed for estimating the cost of oil spills at the EPA Freshwater Spills symposium in April of 2004.[69] The model was developed from a record of historical oil spill case studies, primarily in inland waterways, and provides a methodology for estimating the cost of an oil spill based on the amount spilled, spill location, and material spilled, among other variables. PHMSA elected not to rely on them but cites other studies by the same author that produce costs per gallon of more than $300.

PHMSA received several comments on its monetary estimate of crude and ethanol spills, but no specific citations to literature or other incidents which substantiate a figure other than the one used at the NPRM stage.

To estimate total property damage, remediation, and cleanup costs as well as socioeconomic costs and lasting environmental damages in the baseline, PHMSA multiplied the total estimated quantity to be released in future mainline derailments by $200. PHMSA estimated elsewhere in this analysis that the average expected release in the event of an accident will be 83,602 gallons. PHMSA noted that at a cost of $200 per gallon released, this implies that the average crude oil

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[69] Etkin, 2004. Modelling Oil Spill Response and Damage Costs. EPA Freshwater Spills Symposium. Available online at http://www.environmental-research.com/erc_papers/ERC_paper_6.pdf

and ethanol mainline derailment results in $16.7 million in total costs (including property damages, cleanup, remediation, emergency response, socioeconomic and lasting environmental damages but excluding deaths and injuries).[70]

Monetization of Deaths and Injuries

To fully monetize these events, we also considered injuries and fatalities. There were one fatality, three injuries that involved hospitalization, and 10 injuries that did not involve hospitalization resulting from crude and ethanol shipments by rail between 2006 and 2014. PHMSA used these incidents to estimate injury and fatality damages per carload shipped for crude and ethanol shipments. PHMSA then monetized these damage estimates and adjusts them by the derailment forecast presented above to account for baseline improvements in industry safety performance. We valued the fatalities at the 2014 Value of a Statistical Life (VSL) as per DOT guidance.[71] The injuries resulting in hospitalization were assumed to be severe injuries on the Abbreviated Injury Scale (AIS), and valued at 26.6 percent of the VSL as per DOT guidance. There were ten injuries that did not involve hospitalization associated with crude and ethanol shipments. These injuries were assumed to be minor on the AIS scale and valued at 0.3 percent of the VSL as per DOT guidance. The Table below presents the fatalities, injuries, and carloads shipped from 2006-2013 for crude and ethanol.

Table EB6. Historic Deaths and Injuries in Crude and Ethanol Mainline Derailments with Carloads Shipped

Year	Sum of Total Hazmat Fatalities	Sum of Total Hazmat Hospitalization Injuries	Sum of Total Hazmat Non-Hospitalization Injuries	Carloads
2006	0	0	0	144,238
2007	0	1	0	206,553
2008	0	0	2	301,636
2009	1	2	6	369,172
2010	0	0	0	446,639
2011	0	0	0	475,025
2012	0	0	2	607,014
2013	0	0	0	828,760
2014 (estimated)	0	0	0	957,052
Grand Total	1	3	10	4,336,089

[70] 83,602 gallons released x $300 per gallon lost = $25,080,600.

[71] http://www.dot.gov/office-policy/transportation-policy/guidance-treatment-economic-value-statistical-life.

The total cost of fatalities and injuries was $17.2 million. Divided by the total crude and ethanol carloads shipped, this came to $3.51 per carload shipped in societal damages. These unit figures were multiplied by the of the forecast number of carloads to calculate expected societal damages for crude oil shipments through 2034.

Baseline Fleet Projections

One further adjustment was made to account for the fact that the industry has recently committed to building only enhanced jacketed CPC-1232 cars for crude oil service going forward. These cars are expected to grow to 34 percent of the fleet by 2019 even without regulatory intervention, due to demand for more cars to ship crude oil. A jacketed, thermally protected CPC-1232 car, with improved pressure relief valves and bottom outlet valves, is significantly safer than either a jacketed or unjacketed DOT-111 tank car. As discussed in the tank car effectiveness section, FRA modelling suggests that 40 percent fewer jacketed CPC-1232 cars would release product in a given derailment relative to a derailment consisting of unjacketed DOT-111s. We therefore adjust our baseline by applying the full expected damages for the 34 percent of the fleet that consists of older tank cars, but only 60 percent of the damages to the remainder of the fleet that would be jacketed CPC-1232 cars. The table below presents how we expect the fleet to evolve going forward if regulations are not adopted.

Table EB7. Expected Evolution of Tank Car Fleet in Absence of Regulation
Baseline CPC-1232 J Fleet Share

Year	Legacy	CPC-1232 J	Total	Legacy %	CPC-1232 J%
2015	61,493	24,933	86,426	0.71	0.29
2016	61,493	31,886	93,379	0.66	0.34
2017	61,493	31,886	93,379	0.66	0.34
2018	61,493	31,886	93,379	0.66	0.34
2019	61,493	31,886	93,379	0.66	0.34
2020	61,493	31,886	93,379	0.66	0.34
2021	61,493	31,886	93,379	0.66	0.34
2022	61,493	31,886	93,379	0.66	0.34
2023	61,493	31,886	93,379	0.66	0.34
2024	61,493	31,886	93,379	0.66	0.34
2025	61,493	31,886	93,379	0.66	0.34
2026	61,493	31,886	93,379	0.66	0.34
2027	61,493	31,886	93,379	0.66	0.34
2028	61,493	31,886	93,379	0.66	0.34
2029	61,493	31,886	93,379	0.66	0.34
2030	61,493	31,886	93,379	0.66	0.34
2031	61,493	31,886	93,379	0.66	0.34
2032	61,493	31,886	93,379	0.66	0.34
2033	61,493	31,886	93,379	0.66	0.34
2034	61,493	31,886	93,379	0.66	0.34

Tables EB8 a & b, below, summarizes damages and assumptions attributable to lower consequence events.

Table EB8a: Summary of Assumptions and Estimates Used in Estimating Lower-Consequence Damages

Data Set Years	Variable	Formula/Input	Base Source
2015-2034	No. of Ethanol Carloads Per Year, 2015-2034	394,977 to 419,078 carloads (depending on year)	EIA Production Projections, DOT Estimates
2015-2034	No. of Crude Oil Carloads Per Year, 2015-2034	723,699 to 1,004,852 carloads (depending on year)	RSI Projections, DOT Estimates
2015-2034	No. of Other Class 3 Flammable Liquid Carloads in HHFT	None	DOT Estimates
DOT Estimate for 2015	No. of Mainline Derailments for Crude and Ethanol Service in 2015	11.90 derailments	Log-linear Trend for Large Volume Hazardous Materials Shipments
2009-2013	Constant rate of crude and ethanol derailments per thousand carloads.	0.010636 derailments per thousand carloads.	FRA Database for All Commodities, STB Waybill Sample for All Commodities, RSI docketed comments on future carloads.
DOT Estimate for 2015	Property/Environmental Damage Cost Per Mainline Derailment	$16,720,400	Product of the Two Variables Below
2014	Avg. Property/Environmental Cost, Per Gallon Released	$200	DOT estimate for final rule (see discussion below)
2006-2014	Avg. Gallons of Product Lost, Per Mainline Derailment	83,602 gallons	PHMSA Database for Crude Oil and Ethanol
2006 --2013	Monetized Non-Hospitalized Injury Risk Per Mainline Derailment	$1,330	Product of .05 (value in next row) x VSL
DOT Estimate for 2015	No. of Non-Hospitalized Injuries Per Mainline Derailment	0.05	FRA Injury Database for Crude Oil and Ethanol
2014	Monetized Cost of Non-Hospitalized Injury (AIS 1)	$27,926	DOT 2014 VSL Guidance, Scaled to 2015
2006-2013	Monetized Hospitalized Injury Risk Per Mainline Derailment	$35,372	Product of the Two Variables Below
DOT Estimate for 2015	No. of Hospitalized Injuries Per Mainline Derailment	0.014	FRA Injury Database for Crude Oil and Ethanol
2014	Monetized Cost of Hospitalized Injury (AIS 4)	$2,476,047	DOT 2014 VSL Guidance, Scaled to 2015
2006-2013	Monetized Fatality Risk Per Mainline Derailment	$447,823	Product of the Two Variables Below
DOT Estimate for 2015	No. of Fatalities Per Mainline Derailment	0.048	FRA Injury Database for Crude Oil and Ethanol
2015	Statistically Monetized Value of Life	$9.3 million	DOT VSL Guidance, Death, updated to 2015 using expected real wage growth

Table EB8a: Summary of Assumptions and Estimates Used in Estimating Lower-Consequence Damages			
Data Set Years	**Variable**	**Formula/Input**	**Base Source**
DOT Estimate for 2015 to 2034	CPC-1232 Jacketed Share without Regulation,	0.29% to 0.34% (depending on year)	Railway Supply Institute at NTSB Forum, 4/22/14; DOT Estimate for Future Years
2014	Risk Reduction, CPC-1232 Jacketed Relative to Weighted Average DOT-111 Tank Car	40%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Other Features

Table EB8b: Crude Oil and Ethanol Service: Other Lower-Consequence Damages Estimates and Assumptions		
Variable	**Formula/Input**	**Source**
Difference in Property/Environmental Damages Per Derailment Between Crude Oil and Ethanol	None	DOT Estimate
Difference in Monetized Injury Risk Per Derailment Between Crude Oil and Ethanol	None	DOT Estimate
Change in Share of Crude Oil and Ethanol Production that Travels on HHFT	None	DOT Estimate
Total Property/Environmental Damages from Yard Derailments	Not Estimated	DOT does not expect yard movement damages to materially decrease with this rule
Total Monetized Injury Damages from Yard Derailments	Not Estimated	DOT does not expect yard movement damages to materially decrease with this rule
Total Property/Environmental Damages from Non-Accident Releases (NARs)	Not Estimated	DOT does not expect NARs damages to materially decrease with this rule
Total Monetized Injury Damages from Non-Accident Releases (NARs)	Not Estimated	DOT does not expect NARs damages to materially decrease with this rule
Cars Derailed, Per Mainline Derailment	Not Estimated	Estimate implied in the average of 83,602 gallons of product lost per mainline derailment
Conditional Probability of Release, Per Derailed Car	Not Estimated	Estimate implied in the average of 83,602 gallons of product lost per mainline derailment
Avg. Gallons Lost, Per Releasing Car	Not Estimated	Estimate implied in the average of 83,602 gallons of product lost per mainline derailment

Table EB9 shows the total estimated damages for lower consequence accidents over the next 20 years. These values include both crude and ethanol.

For each year, we calculated the figures in the column labeled "Predicted Damages" in Table EB9 by using the equation:

$$\boldsymbol{Accidents\ in\ a\ YearY\ x\ 83,602\ (Gallons\ Spilled\ per\ Accident)\ x\ \$200 = Monetized\ Damanges\ in\ a\ Year}$$

Where:

$\$200 = The\ Monetized\ Cost\ in\ Damages\ per\ Gallon\ of\ Product\ Released$
$Accidents\ in\ a\ Year Y = Expected\ No.\ of\ Mainline\ Derailments$
$83{,}602\ Gallons = Expected\ Quantity\ Lost\ per\ Year\ (see\ Table\ EB8a)$

From there, we calculated the total expected LCE societal damages, which are represented in the figures in the column labeled "Total Damages" in Table EB9 and following formula.

$$Total\ Societal\ Damages\ for\ LCE=$$
$$[Total\ Damages\ Prior\ to\ Adjustment\ x\ 0.66(Portion\ of\ Legacy\ Cars)]" +$$
$$[0.34(Portion\ of\ Jacketed\ CPC\ Cars)\ x\ 0.60 Safety\ of\ CPC\ Cars\ in\ Service]$$
$$x\ Total\ Damages\ Prior\ to\ Adjustment$$

Table EB9: Expected Societal Damages

Year	Predicted Damages, Unadjusted	Predicted Damages, Adjusted for Change in Fleet Composition	Injury & Fatality Damages, Adjusted for Change in Fleet Composition	Total Damages
2015	$198,943,332	$175,986,171	$3,929,242	$179,915,412
2016	$199,823,175	$172,529,914	$3,897,528	$176,427,442
2017	$206,961,703	$178,693,410	$4,084,398	$182,777,809
2018	$222,253,798	$191,896,803	$4,437,946	$196,334,749
2019	$235,930,200	$203,705,186	$4,766,625	$208,471,811
2020	$250,617,527	$216,386,414	$5,123,109	$221,509,522
2021	$251,894,737	$217,489,173	$5,209,978	$222,699,151
2022	$252,237,661	$217,785,258	$5,278,632	$223,063,891
2023	$235,504,432	$203,337,572	$5,340,648	$208,678,220
2024	$252,899,295	$218,356,522	$5,418,118	$223,774,639
2025	$252,231,674	$217,780,089	$5,467,580	$223,247,669
2026	$247,456,360	$213,657,021	$5,427,362	$219,084,383
2027	$226,784,445	$195,808,622	$5,403,715	$201,212,338
2028	$239,427,362	$206,724,680	$5,375,926	$212,100,606
2029	$235,100,740	$202,989,019	$5,341,069	$208,330,088
2030	$230,476,263	$198,996,186	$5,297,794	$204,293,980
2031	$226,337,503	$195,422,727	$5,264,051	$200,686,778
2032	$222,025,417	$191,699,616	$5,224,695	$196,924,311
2033	$218,216,353	$188,410,821	$5,195,654	$193,606,475
2034	$214,598,192	$185,286,854	$5,169,799	$190,456,652
			Total Undiscounted	$4,093,595,927
			Total Present Value at 7% Discount Rate	$2,151,588,358
			Total Present Value at 3% Discount Rate	$3,037,792,406

Higher-Consequence Event Damages

In order to consider the full impacts of this rule, it is necessary to examine the potential for HHFT accidents greater in number or severity than those observed to date in the U.S. While there have been no higher-consequence events (HCE) in the U.S., we believe that such an event is possible. In the previous section we projected damages that might occur if the rate and size of future accidents were similar to the existing U.S. safety record. In this section, we consider whether, in addition to these projected accidents, there might be one or more higher-consequence events. Therefore, any benefits related to preventing or mitigating the accidents examined in this section would be in addition to the benefits from preventing or mitigating the lower-consequence accidents in the previous section.

A high consequence event is characterized by large-scale property damage and multiple fatalities. The only higher-consequence event in the North American crude and ethanol accident history occurred in the town of Lac-Mégantic, Quebec, in July of 2013. The event involved an unattended train that rolled downhill and resulted in a 63-car derailment at 65 mph. The derailment caused a spill of approximately 1.5 million gallons and resulted in the deaths of 47 people and the destruction of much of the downtown area with oil spreading more than 100 kilometers down the Chaudiere River.[72] A year after the event, decontamination of the soil and water/sewer systems is still ongoing. Cleanup of the lake and river that flows from it has not been completed, and downstream communities are still using alternative sources for drinking water. Initial estimates of the cost of this event were roughly $1 billion, but the cleanup costs have doubled from initial estimates of $200 million to at least $400 million, and estimates of the total cost to clean up, remediate, and rebuild the town have risen as high as $2.7 billion.[73]
The frequency and magnitude of these events is highly uncertain. It is, therefore, difficult to predict with any precision how many of these higher-consequence events may occur over the coming years, or how costly these events may be. In the worst-case scenario for a fatal event, the results could be several times the damages seen at Lac-Mégantic both in loss of life and other associated costs.

Estimated Magnitude of a Higher-Consequence Event

We examined -two possible methods for estimating the damages that might result from a higher-consequence event. The first method would be to use the existing U.S. safety record and scale up the damages of one or several of the larger rail accidents in the record to account for possible risk factors that might exacerbate the consequence of the incident if a similar accident were to occur under different circumstances. Risk factors include condition of the track and supporting

[72] http://www.montrealgazette.com/health/Huge+scope+M%C3%A9gantic+cleanup+comes+into+focus/9348298/story.html

[73] http://www.pressherald.com/2014/04/17/after-end-of-the-world-explosion-lac-megantic-aims-to-rebuild/

infrastructure; the presence or absence of signals; past incidents; population density along the route; environmentally-sensitive or significant areas; venues along the route (stations, events, places of congregation); emergency response capability along the route; measures and countermeasures already in place to address apparent safety and security risks; and proximity to iconic targets. For example, a 2009 19-car derailment in Cherry Valley, IL spilled about 230,000 gallons of ethanol, caused a fire resulting in 1 fatality, 2 injuries, and $7.9 million in property damages, according to the NTSB. If this event had occurred in a more populated area, the consequences could have been significantly larger. This approach would involve placing such an event in another location, and adjusting total costs according to the likely increase in the value of property damaged and number of fatalities that may have resulted. For instance, property values and population densities are much higher in Chicago, IL. If a similar event occurred in Chicago the value of the property damaged would have been much higher, and the damaged infrastructure may have imposed much larger delay costs to commuters and the overall rail network. In addition, more injuries and fatalities may have resulted, though it would be difficult to predict how many fatalities would result from such an event given that fatalities would depend on the exact concentration of people in a particular place at a particular time.

This exercise could be conducted for several other recent events involving crude oil and ethanol. For example, the derailment in Arcadia, OH, occurred very close to a fertilizer plant. Had the derailment hit the ammonia plant, an ammonium nitrate explosion there could have been an explosion the same order of magnitude as the one that occurred in West, TX,74 and the damages would have been much more severe. The train that derailed and punched a 35-foot hole in the wall of an industrial facility in Vandergrift, PA in January of 2014 was carrying heavy crude.75 Had that train been loaded with more easily ignited ethanol or light, sweet crude, a violent release of ignited flammable liquid may have occurred, potentially killing some or all of the 65 employees working at the facility. Alternatively, if the same derailment occurred in the neighboring borough of East Vandergrift the consequences might have been much worse. The derailment in Lynchburg, VA, had it occurred to the town rather than riverside of the track, may have hit a busy lunchtime eatery, resulting in multiple fatalities despite the fact that only one car ruptured. A derailment on a bridge upstream from a reservoir that supplies drinking water to several communities or one large city could result in extensive costs to the municipality if the reservoir were contaminated and the communities that rely on it had to find an alternative supply for drinking water. A recent example of a release of a chemical into a river system impacting drinking water supplies occurred on January 9, 2014. In this case, a chemical leak at the Freedom Industries site that seeped into West Virginia's Elk River a mile and a half upstream of the state's largest water intake. As a result, a "Do Not Use Water Notice" was placed West Virginia American Water customers across nine West Virginia counties. While this release occurred from

[74] http://www.csb.gov/west-fertilizer-explosion-and-fire-/

[75] http://www.reuters.com/article/2014/02/13/us-energy-crude-derailment-idUSBREA1C13120140213

storage tanks at a fixed facility, the amount of product released (approximately 10,000 gallons) with an unknown amount that entered the river is similar to the circumstances that often surround releases from rail accidents.[76] Scaling up these events based on differences in location, tank car contents, or events, would require making assumptions about when and where such events might have occurred and what consequences would have resulted from those events in alternate locations. Clearly, from the above examples, slight adjustments in the assumed characteristics of an event could result in dramatic increases in event consequences. It is unclear to PHMSA what assumptions would be reasonable.

PHMSA acknowledges that event severity, especially property damage, is likely to be correlated with total quantity of product released, the geographic and environmental aspects of the location in which the event occurs, the proximity of high concentrations of people in said vicinity. Ideally, given enough information, PHMSA would adjust high consequence event damages for all of these factors.

Monte Carlo Approach to Estimating Higher-Consequence Event Damage

For the second method PHMSA developed a risk model to estimate a range of estimates associated with the projected higher-consequence events. PHMSA used a probabilistic risk model, specifically a Monte Carlo simulation to estimate a range of damages that could be observed in future high consequence events (HCE). This model serves as the basis for estimating HCE damages in the final rule. This allowed us to account for the inherent uncertainties in forecasting the frequency and severity surrounding these events.[77]

The Monte Carlo simulations consider uncertainty in the following six factors: (1) Non-Fatality Damages; (2) the Percent of Fatalities within the affected Population per accident; (3) location of the accident (random selection of population density); (4) the expected number of high consequence events that will occur over the next 20 years; (5) damages to wetlands; and (6) the probability of damages to wetlands.

(1) Non-fatality damages

PHMSA used the estimated damages of the accident at Lac-Mégantic, Quebec, scaled down to be more representative of expected damages from a high consequence event in the U.S., to estimate the potential benefits of mitigating higher-consequence events. We acknowledge that

[76] http://www.epaosc.org/site/site_profile.aspx?site_id=9021

[77] Monte Carlo simulation performs an analysis by building models of possible results by substituting a likely range of values for any factor that has inherent uncertainty. The simulation then calculates results over and over, each time using a different set of random values from the probability functions, to generate a probability distribution of possible outcomes.

there is uncertainty about the potential magnitude of damages from any high consequence event, since there has only been one such event in North American rail history.

PHMSA estimates the total (fatality plus non-fatality) damages from Lac-Mégantic at $1.1 billion and non-fatality damages of $658 million. There is evidence to suggest that this estimate may be conservative. The event at Lac-Mégantic Quebec produced damages close to half a billion dollars in terms of loss of life (47 deaths at an assumed value of a statistical life of about $10 million). Cleanup costs associated with the event, which had initially been estimated at $200 million, are now being estimated at twice that amount.[78] Further it is still unclear when the lake and river that drain from the lake will be completely cleaned up, and nearly the entire downtown has yet to begin reconstruction a year later. The value of lost business activity, temporary unemployment of those working at the businesses destroyed, and other costs may be much more than the initial estimates on which the $1.1 billion figure are based suggest. Recently Canadian officials provided an unofficial estimate of $1.5 billion for the non-fatality damages associated with the incident. Although the Canadian government is uncomfortable placing a value on human life, using the current USDOT VSL of approximately $10 million as noted above the total damages associated with the Lac Mégantic incident would rise to roughly $2 billion.

While PHMSA uses the damage estimates from the Lac-Mégantic event in estimating the higher consequence event damages in the U.S., we acknowledge this accident was unique in many ways. For example, it is highly unlikely that there would be a derailment at 65 mph and the tank car standards proposed here are not intended to be sufficient to prevent or mitigate a puncture at this speed and force—the highest speed of derailments in the U.S. safety record for ethanol and crude is 48 mph, and the rail industry has agreed to limit speeds for crude and ethanol unit trains to 50 mph. Similarly, it is highly unlikely that a 63-car derailment would occur—the largest derailment in the U.S. crude and ethanol record is a 31-car derailment. Thus, PHMSA scales down the damages from Lac-Mégantic detailed below, to account for a smaller expected number of cars derailed and lower speeds of an expected high consequence event in the U.S. We believe extraordinary damages could have occurred even if the train in Lac-Mégantic had derailed at a slower speed. There have been large pool fires in many derailments that occurred at slower speeds. For example, the accidents in Arcadia, OH, Aliceville, AL and Casselton, ND had pool fires.[79]

PHMSA considered various methodologies to estimate a factor for scaling down the damages from Lac- Mégantic. Among the alternatives considered were the following: (a) scaling solely as a function of differences in expected train speed, (b) scaling solely on the basis of differences in expected cars derailed, (c) scaling solely on the basis of differences in expected cars punctured,

[78] http://www.pressherald.com/2014/04/17/after-end-of-the-world-explosion-lac-megantic-aims-to-rebuild/

[79] See Appendix B for full details of these events.

and (d) scaling on the basis of differences in kinetic energy. PHMSA conservatively uses the kinetic energy approach, which directly takes account of the differences in energy between accidents at different speeds. Kinetic energy is a function of both mass and velocity; consultations with engineers and subject matter experts indicate differences in kinetic energy are likely to translate into proportional reductions in the severity of an accident.[80] FRA identified all crude oil and ethanol rail corridors within the U.S. totaling 20,420 rail links.[81] Rail link lengths range from 0.005 to 25 miles, with average link length of 1.8 miles. FRA identified the *high-threat urban areas* (HTUA)[82] along the fuel rail network as defined by the Department of Homeland Security within the High-Hazard Flammable Train (HHFT).[83] PHMSA applied different scaling factors for the Lac-Mégantic damage estimates that yield separate baseline damage estimates in the non-HTUA portion of fuel rail network and a different baseline damage estimate for the HTUA portion of fuel rail network.

To estimate the scaling factor in the non-HTUA portion of fuel rail network PHMSA compared the differences in speed between the accident in Lac- Mégantic (65 mph) and that which might be expected to occur in the U.S. PHMSA estimated the average speed for the largest (in terms of volume spilled) 10% of accidents in the U.S. crude and ethanol accident history. These accidents were New Brighton (37 mph at derailment), Arcadia (46 mph), Aliceville (39 mph), and Casselton (42 mph). Averaging across these accidents, we obtained average derailment speed of 41 mph. The reduction in kinetic energy of going from 65 mph to 41 mph is about 60%. Applying this reduction in energy to the damages in Lac-Mégantic results in a scaled estimate of total damages of about $440 million ($1.1 billion × (100% - 60%)) and non-fatality damages of $263 million ($658 million × (100% - 60%)). Similarly, to estimate the baseline damages in the HTUA portion of fuel rail network, PHMSA estimated that the reduction in kinetic energy of going from 65 mph to 35 mph[84] is about 71%. Applying this reduction in energy to the damages

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[80] Kinetic energy varies directly with the square of speed (velocity). [Kinetic energy = ½ Mass x $(\text{Velocity})^2$]. 40 mph is 80% of 50 mph. Assuming equal mass, the resulting change in energy is the square of the difference in velocity ($0.8^2 = 0.64$) or a reduction of 36% (1.00 - 0.64 = 0.36).

[81] Total fuel rail network length is approximately 36,500 miles.

[82] Fuel rail network length in HTUAs is approximately 2,400 miles.

[83] Fuel rail network length is approximately 34,000 miles.

[84] Railroad subscribers agreed to adhere to a speed restriction of 40 mph for any HHFTs carrying crude oil in HTUAs, unless the tank cars all meet the CPC-1232 standard. This rulemaking will extend that speed restriction for HHFTs carrying ethanol, and will change the threshold tank car standard to the DOT-117 or DOT-117p. Thus PHMSA expects that any HCEs that occur in HTUAs will be at somewhat lower speeds than the 41 mph assumed for HCEs in the non-HTUAs portion of the fuel rail network. For this reason, PHMSA assumed conservatively the reduction in kinetic energy in the HTUA portion of fuel rail network of going from 65 mph to 35 mph.

in Lac-Mégantic results in a scaled estimate of total damages of about $319 million ($1.1 billion × (100%-71%)) and non-fatality damages of $191 million ($658 million × (100%-71%)).

For purposes of this estimate, the total damages include fatalities,[85] non-fatality damages include property damage to the town, environmental and other cleanup costs, the costs associated with re-routed train traffic, evacuation and emergency response costs, and the value of the rail cars and oil that was lost.

(2) The Percent of Fatalities within the affected Population per accident

The expected number of fatalities from a high consequence ethanol or crude oil accident is estimated using data on the population density in census blocks near railroad tracks. Population density is likely to affect the size of any property damages and the number of any injuries or fatalities. The presence of a place of congregation was a particularly important factor in the damages from Lac-Mégantic. While imperfect, population density is a proxy for the presence of places of congregation. This risk model used the scaled down damage estimate for the Lac-Mégantic accident as described above in conjunction with an estimated population density of the areas within a half-square km of crude oil and ethanol routes in the U.S. Scaling potential risk by population density is a technique used frequently in the literature on the safety of hazardous material shipments. For example Verma uses population exposure as a component of a risk assessment framework for hazardous materials shipments by rail.[86,87] Glickman et al. uses population density as a risk factor to be used in making rail routing decisions for hazardous materials shipments.[88] Saat and Barkan use the number of people affected, which is a function of population density, to scale the consequence levels of hazardous materials rail accidents.[89]

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[85] The U.S. Department of Transportation (USDOT) has established a Value of Statistical Life (VSL) of $9.2 million for 2014 (http://www.dot.gov/policy). USDOT's guidance specifies that the VSL is expected to rise by 1.18 percent per year in response to expected increases in real incomes. That means that, over the 20-year analysis period, the VSL will rise to a value of $11.96 million in the 20th year, and will have an average value over the 20 years of the analysis of $10.72 million. PHMSA uses this value to monetize the casualty costs.

[86] Verma, Manish. 2009. Railroad transportation of dangerous goods: a conditional exposure approach to minimize transport risk. Transportation research part C.

[87] Verma, Manish. 2009. A cost and expected consequence approach to planning and managing railroad transportation of hazardous materials. Transportation research part D

[88] Glickman, Theodore S., Erkut, Efhan, and Zschocke, Mark S. 2007. The cost and risk impacts of rerouting railroad shipments of hazardous materials. Accident Analysis and Prevention. 39. 1015-1025.

[89] Saat, M. Rapik, and Barkan, P.L. 2006. The effect of rerouting and tank car safety design on the risk of rail transport of hazardous materials. Proceedings of the 7th world congress on railway research. Montreal. June.

Kawprasert also uses population density as a factor that influences hazardous material risk.[90] It seems reasonable, given this body of research, to scale our damages to the population densities along the U.S. crude and ethanol routes.

Ideally, the model would have looked at populations very close to the tracks, where the damages from a derailment would be expected to occur. Unfortunately, population data was only readily available by Census blocks for areas throughout the U.S. rail network. In urban areas, Census blocks may be quite small, allowing very granular measurements of populations close to the tracks. However, in more rural areas, Census blocks tend to be considerably larger in area and may not accurately capture the size of populations close to the tracks. If population density is higher away from the tracks, using Census block data will tend to overstate the population close to the track. If population with the block is clustered close to the tracks, then using Census block data will tend to understate the population close to the track.

Another complication of using Census block data is that these data reflect where people live, rather than where they actually are at any particular time of day. For example, Census block data may list a relatively low population within the central business districts of some cities, but there might be a very large number of people working there in the middle of the day. While there are shortcomings to using Census block data, many of these under- or overestimates tend to balance out. Without a much more labor-intensive examination of the areas surrounding individual segments of track, use of Census block data appears to be the most reasonable approach available for estimating populations located close to tracks.

The average fatality rate for high consequence events in the U.S. is assumed to be equal to the fatality rate in Lac-Mégantic multiplied by the scaling factors used to account for likely lower kinetic energy in high consequence events. As with the estimate of non-fatality damages in (1) above, we take into account differences in kinetic energy in the non-HTUA portion of fuel rail network and the HTUA portion of fuel rail network. The fatality rate for these two portions of the network are calculated as follows:

(47/136) × 0.40 scaling factor = 14% in the non-HTUA portion of fuel rail network and (47/136) ×0.29 = 10% in the HTUA portion of fuel rail network, where 47 is the number of fatalities associated with the Lac Mégantic accident, 136 is the average population density per half-square km in the town of Lac Mégantic (and 47/136 yields the fatality rate for that accident), and 0.40 = (100% - 60%) is the scaling factor in the non-HTUA portion of fuel rail network and 0.29 = (100% - 71%) is the scaling factor in the HTUA portion of fuel rail network.[91]

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[90] Kawprasert, Athaphon. 2010. Quantitative analysis of options to reduce risk of hazardous materials transportation by railroad. Ph.D. Dissertation in civil engineering. University of Illinois at Urbana-Champaign.

[91] The accident in Lac- Mégantic, Quebec, resulted in 47 fatalities. In estimating the higher-consequence event damages in the U.S., PHMSA scaled down the damages from Lac- Mégantic by 60% in the HHFT (other than

(3) Location of the accident (random selection of population density)

In addition, PHMSA assumed the risk of accident damage scales with the length of individual fuel rail links. FRA identified all crude oil and ethanol rail corridors within the U.S. totaling 20,420 rail links.[92] Rail link lengths range from 0.005 to 25 miles, with average link length of 1.8 miles. FRA identified the *high-threat urban areas* (HTUA)[93] along the fuel rail network as defined by the Department of Homeland Security within the High-Hazard Flammable Train (HHFT)[94] set of data and provided the average annual tons transported [95] to select in which area the accident occurs. The table below provides a sample of the population densities and rail link lengths for the fuel network provided by the FRA. FRA obtained these population density estimates as shown in Appendix D. The risk model performs a random selection of a population density from custom distributions with points given by the population densities in HTUAs and non-HTUAs as illustrated in the table below. The fuel network rail link lengths are used within HTUA/non-HTUA as a scaling factor to develop the population density custom distributions for HTUAs and non-HUTA networks, assuming the probability the model randomly determines a location and impact based link length and usage.[96] PHMSA uses the average annual tons transported on the fuel network to select in which area the accident occurs and is a proxy for the usage of the rail track in the HTUAs versus the rest of the HHFT network.

HTUAs) portion of fuel rail network, respectively by 71% in the HTUA portion of fuel rail network. PHMSA estimated the number of fatalities the higher-consequence event in the U.S. would also be 60% lower in the HHFT(other than HTUAs) portion of fuel rail network and respectively 71% lower in the HTUA portion of fuel rail network.

[92] Total fuel rail network length is approximately 36,500 miles.

[93] Fuel rail network length in HTUAs is approximately 2,400 miles.

[94] Fuel rail network length is approximately 34,000 miles.

[95] The average annual tons transported on the HHFT, respectively the HTUA network were developed by assigning the 2013 Confidential Waybill Sample, specifically for crude and ethanol, to the rail network. The Department of Homeland Security supplied a polygon layer for the HTUAs. Tons are by individual rail link. Note that the tons on each waybill are assigned to each link that the waybill record traffic traverses between origin and destination. The average annual tons transported on the fuel network data was provided by the FRA to PHMSA on December 19th as follows: 8,009,851,408 tons for the HTUA network, and respectively 49,800,510,555.7 tons for the entire HHFT network.

[96] PHMSA uses the average annual tons transported on the fuel network to select in which area the accident occurs and is a proxy for the usage of the rail track in the HTUAs versus the rest of the HHFT network as described later in this section.

Table EB 10. Sample Population Densities Along Crude Oil and Ethanol Rail Routes

Rail Link Length	Population Density (per square mile)	Population Density (per half-square kilometer)*	Probability of an Accident Occurring Along a Given Rail Link**	Cumulative Probability of an Accident
0.35	934.52	180.41	0.001%	0.0010%
0.10	934.63	180.43	0.000%	0.0012%
0.73	935.02	180.51	0.002%	0.0032%
4.34	935.13	180.53	0.012%	0.0151%
4.55	935.83	180.66	0.012%	0.0276%
10.74	935.86	180.67	0.029%	0.0570%
0.80	936.16	180.73	0.002%	0.0592%
3.03	936.58	180.81	0.008%	0.0674%
4.08	936.91	180.87	0.011%	0.0786%
0.09	937.13	180.91	0.000%	0.0788%
1.19	937.21	180.93	0.003%	0.0821%
0.10	937.36	180.96	0.000%	0.0824%
5.38	937.38	180.96	0.015%	0.0971%
0.16	937.66	181.02	0.000%	0.0975%
0.17	937.78	181.04	0.000%	0.0980%
0.34	938.19	181.12	0.001%	0.0989%
0.24	938.28	181.14	0.001%	0.0996%
0.33	938.34	181.15	0.001%	0.1005%
0.02	938.37	181.15	0.000%	0.1005%
0.56	938.53	181.18	0.002%	0.1021%
0.22	938.56	181.19	0.001%	0.1027%
4.93	938.58	181.19	0.013%	0.1162%
6.41	938.80	181.24	0.018%	0.1337%
0.02	938.91	181.26	0.000%	0.1338%
0.29	939.22	181.32	0.001%	0.1345%
0.35	939.22	181.32	0.001%	0.1355%
2.11	939.85	181.44	0.006%	0.1413%
0.26	939.87	181.44	0.001%	0.1420%
0.48	939.94	181.45	0.001%	0.1433%
3.91	939.96	181.46	0.011%	0.1540%
6.82	940.58	181.58	0.019%	0.1727%

*PHMSA calculated this column, “Population Density per Half-Square Kilometer (sq km)”, by using this equation:

$$\frac{Population\ Density\ per\ Sq\ Mile}{5.18\ half\ sq\ km/Sq\ mile}$$

For example:

If $1\ mile = 1.609344\ kilometers$

Then $1\ sq\ mile = 2.59\ sq\ km$

Then $1\ half\ sq\ km = \frac{1\ sq\ mile}{2.59\ sq\ km\ x\ 2}$

And $1\ half\ sq\ km = \frac{1\ sq\ mile}{5.18}$

**To calculate the column, "Probability of an Accident Occurring Along a Given Rail Link," PHMSA assumed that the probability of an accident is proportional to the link length.

This probability is represented by the equation:

$$\frac{Rail\ Link\ Length}{Total\ Rail\ Fuel\ Network\ Length}$$

For example, in the HHFT network, for a 0.35 stretch of rail:

$$\frac{0.35\ Miles\ of\ HHFT\ Rail\ Link}{34{,}000\ Total\ Miles\ of\ HHFT\ Fuel\ Rail\ Network} = 0.001\%\ Probability\ of\ an\ Accident$$

Therefore, a 100-kilometer link has twice the likelihood of an accident as a 50-kilometer link, and the population density associated with the 100-km link has twice the likelihood of being chosen as the population density of the 50-km link.

(4) The expected number of high consequence events that will occur over the next 20 years
Next, PHMSA forecasts the number of higher-consequence events that are likely to occur in the absence of this rule over the next 20 years (2015 – 2034).

To do this:

1) PHMSA used the historical number of carloads in the U.S. and Canada to establish a baseline of crude and ethanol shipments. Between 1995 through 2013,[97] there were approximately 4 million carloads of crude oil and ethanol shipped in the U.S. from and over 1 million carloads shipped from Canada between 1999 and 2013.[98]
2) We forecasted the number of carloads expected to ship between 2015 and 2034. PHMSA estimates approximately 26.2 million carloads of crude oil and ethanol will be shipped in the U.S.[99]
3) PHMSA used these numbers in the following equation to forecast the number of higher-consequence events over the next 20 years. It is important to mention that between 1995 and 2013, only one event that fits the "higher-consequence" profile occurred; the Lac-Mégantic accident in Canada on July 6, 2013.

$$\frac{Forecast\ of\ U.S.\ Only\ Carloads\ Shipped\ (2015-2034)}{Total\ No.\ of\ Carloads\ Shipped\ in\ U.S.\ and\ Canada}$$

For example,

$$\frac{26.2\ U.S.\ Only\ Carloads}{5.3\ Total\ Carloads} = 4.94\ Forcasted\ HCE\ events$$

Thus, PHMSA estimates the number of higher-consequence events that are likely to occur over the next 20 years in the absence of this rule at up to five events. PHMSA chose a triangular distribution for the number of events distribution in the risk model. Additionally, with definite lower and upper limits we avoided extreme values. PHMSA assumed a point estimate of 2 events with one event and five events as the lower and upper bounds in the risk model. PHMSA estimated conservatively a point estimate of 2 events by taking into account the risk of derailments being reduced by the voluntary actions taken by the railroads including (e.g., speed

[97] Surface Transportation Board (STB) Public Waybill Sample carloads data.

[98] Source: Statistics Canada, "Table 404-0002 – Railway carloading statistics, by commodity, monthly" accessed January 23rd, 2015": 1,058,217 carloads of "Fuel oils and crude petroleum" data. Statistics Canada does not further break down the commodity referred to as "Fuel oils and crude petroleum". Thus, PHMSA assumed all carloads shipped under this category are crude petroleum. There is a total of 453,227 carloads under the category called "Gasoline and aviation turbine fuel", and a total of 63,744 carloads under the category "Alcoholic and non-alcoholic beverages." Statistics Canada mentioned "Ethanol and Gasoline Mixture" can be found under the category called "Gasoline and aviation turbine fuel", and "Ethanol or ethyl alcohol" under the category "Alcoholic and non-alcoholic beverages". However, Statistics Canada does not provide the share of carloads of ethanol as a detailed commodity. Thus, PHMSA assumed ethanol comprises half of the carloads under the last two categories "Gasoline and aviation turbine fuel" and "Alcoholic and non-alcoholic beverages" for a total of 258,486 carloads. The total number of crude petroleum and ethanol shipped by rail in Canada from 1999 to 2013 is 1,058,217 + 258,486 = 1,316,703 carloads.

[99] Please, see Section B. *Final Rule Analysis* in the RIA.

restrictions in HTUAs and routing requirements). PHMSA assumed one event as the lower bound and not zero events because zero HCE events are assumed in the calculation of expected damages associated with lower consequence events. That is, the lower bound of total benefits from this rule represents damages from avoiding LCE events and zero HCE events; the upper bound of benefits associated with this rule arise from avoiding both LCE and a positive number of HCE events (between 1 and 5 HCE events).

(5) Damages to wetlands

PHMSA estimates the clean-up costs for impacted wetlands at $14.7 million per incident based on the values shown in Appendix D. PHMSA evaluated and included wetlands impacts in the risk model to more accurately quantify the higher-consequence event damage estimate.

(6) The probability of damages to wetlands

FRA found that 2 percent of the fuel oil rail network is within 0.28 miles of a wetland and for larger oil spills 10 percent of the fuel oil rail network is within 0.5 miles of a wetland. These estimates were developed based upon expert opinion and previous US accident reports where rail car contents reached the wetland area. The 6% point estimate is the average between the 2% and 10% values mentioned above.

The fatality and non-fatality damages are dependent on the draw of the population density random variable. However, any realized values will be highly correlated.[100,101] The model represents a Monte Carlo simulation by substituting a range of values for these factors that have inherent estimation uncertainty as seen in the table below:

[100] PHMSA expects that for any accident the fatality and non-fatality damages would both be high or low at the same time. Statistically speaking, this means they are highly correlated. Clearly, a highly populated area generally has more buildings and other infrastructure that can be impacted as well as more people. It is possible, however, for these to not occur simultaneously, for example, an expensive warehouse with few people in the area would have high non-fatality damage and low number of fatalities. The model applies randomness to selected variables to allow for a Monte-Carlo analysis (numerous iterations to allow for statistical solution when analytic solutions are not feasible) of the system.

[101] We also ran this model with the same inputs but held fatality and non-fatality damages fixed. This increased the mean total estimated damages by 4.3 percent.

Table EB11. Assumed Distribution of Input Values for Monte Carlo Analysis					
Risk Variables	**Probability Distribution**	**Point Estimate**	**Low**	**Mode**	**High**
Number of Events	Triangular*	2	50%	100%	250%
Percent of Population Fatalities in HHFT	Triangular*	14%	75%	100%	110%
Percent of Population Fatalities in HTUAs	Triangular*	10%	75%	100%	110%
Baseline Non-Fatality Damages in HHFT	Triangular*	$263,310,064	75%	100%	125%
Baseline Non-Fatality Damages in HTUA	Triangular*	$190,860,845	75%	100%	125%
Random Selection of Population Density	Custom**				
Wetlands	Triangular*	$14,654,932	75%	100%	125%
Wetlands Probability	Uniform	6%	2%		10%

*****We chose a triangular distribution for most elements because of its ease of use, only 3 parameters (lower limit, an upper limit and a mode) and allows for skewed distributions, like the percent fatalities above. Additionally, with definite lower and upper limits we can avoid extreme values.

**The random selection of a population density is based on custom distributions with points given by the population densities in HTUAs and the rest of the HHFT rail network as illustrated in the table titled *Population Densities along Crude Oil and Ethanol Rail Routes*. The fuel network rail link lengths are used within HTUA/non-HTUA as a scaling factor to develop the population density custom distributions for HTUAs and non-HTUA networks, assuming the probability of having an accident is proportional to the link length. PHMSA uses the average annual tons transported on the fuel network to select in which area the accident occurs and is a proxy for the usage of the rail track in the HTUAs versus the rest of the HHFT network. Thus, the probability of an accident occurring in the HTUA portion of the network is given by the ratio between the average annual tons transported in the HTUA network to the total tons transported in the entire HHFT network:
$8{,}009{,}851{,}408 / 49{,}800{,}510{,}555.7 = 0.1608$.
HTUAs account for 16.08 percent of the HHFT network. In each run of the simulation, a new, random number between 0 and 1 is generated. If this number is less than 0.1608, the incident is modeled as if taking place in a HTUA; otherwise, it is modeled as if taking place outside of a HTUA.

The model executes 10,000 iterations on the randomly selected inputs. Assuming an event has an equal likelihood of occurrence every year the model outputs 10,000 different results. The following table EB12 shows a sampling of 30 possible sets of alternative outcomes (and the damages resulting from those outcomes) that might occur over the 20-year analysis period.

The estimates in Table EB12[102] were calculated as follows. The population density scaling factor was calculated by dividing the population density per half-square km for each rail link by 136

[102] The results presented in the table are rounded to the nearest tenth.

(which is the population density per half-square km for Lac-Mégantic). The non-fatality damage estimates were calculated by multiplying the non-fatality damages by the number of events and by the population density scaling factor to account for the likely differences in the density of buildings and other infrastructure relative to that in Lac-Mégantic.[103] The fatality damage estimates were calculated by multiplying the number of events by the percent of population fatalities, the population density, and the average VSL value over the 20-year period of analysis as determined above.[104]

This model randomly applies selected variables to allow for an analysis with numerous iterations to allow for statistical solution of the system. While we expect that for any accident, the fatality and non-fatality damages would both be high or low at the same time this may not always the case.

Wetlands present special environmental impacts, and thus should be included in a cost-benefit analysis. However, many variables can go into evaluating the impact of a spill on wetlands (e.g., type of oil, viscosity of the oil, slope of terrain, weather – all of which will impact the distance and quantity of the spill to reach the wetlands). PHMSA assumed an accident could impact both the wetlands and the population, therefore the wetland impacts are additive to the fatality/non-fatality damage estimates.[105] Below is the table showing a sampling of 30 possible sets of alternative outcomes (and the damages resulting from those outcomes) that might occur over the 20-year analysis period.

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[103] For instance, the value calculated for the first iteration:
$\$172\ million\ =\ (1.66\ x\ 38.9\ x\ \$266\ million)$
Where: "*number of events" x "scaling factor" x "non-fatality damages"*. The number of events 1.66 is rounded to the nearest tenth to 1.7 in Table EB13 "Sample Outputs of the Risk Model Showing 20-Year Values for Fatality and Non-Fatality Damages."

[104] For instance, the value calculated for the first iteration:
$\$107.7\ million\ =\ (1.66\ x\ 11.4\%\ x\ 53\ x\ \$10.72\ million)$
Where: "$number\ of\ events$" x "$percent\ fatalities$" x "$population\ density\ per\ half-square\ kilometer$" x "$average\ VSL\ over\ the\ 20\ year\ period\ of\ analysis$". The number of events 1.66 is rounded to the nearest tenth to 1.7 in Table EB13 " Sample Outputs of the Risk Model Showing 20-Year Values for Fatality and Non-Fatality Damages."

[105] In order to test whether an accident occurred in a wetland, PHMSA implemented a random selection on the wetlands probability between 2 and -10 % (uniform distribution in which we know the range between the minimum and maximum values and that all values in the range are equally likely to occur). This is used to compare with another random field a random number (0-1) and then testing if less the impact occurred and choose the randomly selected wetland probability. PHMSA would need additional data that would target the likelihood of the larger distance criteria, but for now is assumed uniform and equal weighting across all possible values.

Table EB12. Sample Outputs of the Risk Model Showing 20-Year Values for Fatality and Non-Fatality Damages

Trial values	# of Events	Percent Fatalities	Population Density per half-square km	Scaling Factor	Non-Fatality Damages* (million)	Damages Non-Fatality (million)	Damages Fatality (million)	Wetlands (million)	Total Damages (million)
1	1.7	11.4%	53.0	38.9%	$266.0	$172.0	$107.7	$0.0	$279.7
2	4.1	14.1%	8.1	6.0%	$279.2	$68.2	$50.3	$0.0	$118.5
3	3.6	12.4%	226.0	165.9%	$251.5	$1,517.2	$1,096.4	$0.0	$2,613.6
4	1.8	13.6%	169.3	124.2%	$245.1	$533.6	$433.9	$0.0	$967.5
5	1.8	12.9%	280.8	206.1%	$246.9	$917.8	$702.1	$0.0	$1,619.9
6	2.2	14.2%	82.7	60.7%	$294.9	$389.0	$274.1	$0.0	$663.2
7	2.7	11.2%	67.9	49.9%	$229.2	$307.7	$220.2	$0.0	$527.9
8	2.2	13.0%	23.7	17.4%	$251.2	$97.7	$74.1	$0.0	$171.8
9	3.5	12.2%	218.2	160.2%	$317.1	$1,797.1	$1,012.9	$0.0	$2,810.0
10	2.2	13.0%	166.6	122.3%	$228.4	$612.9	$509.4	$0.0	$1,122.4
11	2.0	14.6%	51.7	38.0%	$274.7	$203.9	$158.7	$15.8	$378.5
12	2.4	12.8%	49.4	36.3%	$240.5	$212.5	$165.1	$0.0	$377.6
13	3.1	13.5%	2.3	1.7%	$299.9	$15.6	$10.2	$15.2	$41.0
14	2.9	14.0%	0.3	0.2%	$304.2	$2.2	$1.5	$0.0	$3.6
15	3.9	13.0%	26.4	19.3%	$265.4	$197.9	$141.7	$0.0	$339.6
16	4.2	9.9%	0.0	0.0%	$198.2	$0.0	$0.0	$0.0	$0.1
17	1.3	13.6%	94.5	69.4%	$249.2	$226.8	$181.1	$0.0	$407.9
18	1.6	14.0%	27.4	20.1%	$271.6	$85.2	$64.2	$0.0	$149.4
19	2.3	10.8%	0.6	0.4%	$197.1	$1.9	$1.5	$0.0	$3.5
20	1.5	12.8%	0.2	0.1%	$300.7	$0.5	$0.3	$0.0	$0.9
21	2.0	9.4%	1,499.1	1100.3%	$194.8	$4,197.8	$2,960.5	$0.0	$7,158.3
22	2.5	11.7%	54.8	40.2%	$260.8	$265.6	$173.6	$0.0	$439.2
23	3.7	12.5%	640.5	470.1%	$273.9	$4,815.7	$3,222.0	$0.0	$8,037.6
24	3.2	13.8%	395.9	290.6%	$283.4	$2,667.3	$1,893.5	$0.0	$4,560.9
25	1.6	13.7%	493.1	361.9%	$272.9	$1,628.3	$1,191.6	$0.0	$2,819.9
26	1.3	12.2%	182.0	133.5%	$271.3	$475.1	$311.8	$0.0	$786.9
27	3.4	14.5%	406.1	298.1%	$257.0	$2,640.7	$2,175.7	$0.0	$4,816.4
28	4.0	9.0%	4,028.9	2957.1%	$162.7	$19,224.2	$15,454.4	$0.0	$34,678.7
29	1.9	11.8%	25.9	19.0%	$224.7	$81.0	$62.3	$0.0	$143.4
30	4.6	12.6%	429.8	315.5%	$281.5	$4,093.1	$2,677.3	$0.0	$6,770.5

Note: *The values represent the Lac-Mégantic baseline non-fatality damages and vary randomly according to the triangular distribution of non-fatality damages set forth in table titled *Assumed Distribution of Input Values for Monte Carlo Analysis*.

The distribution of total estimated damages from high-consequence events over 20 years is shown as a percentile distribution from 0 percent to 100 percent in 5-percentile increments as follows:

Table EB13. Distribution of Total Estimated Damages From Higher-Consequence Events Over 20 Years

Percentile	# of Events	Percent Fatalities	Population Density per half-square km	Scaling Factor relative to Lac-Mégantic	Damages Non-Fatality (million)	Damages Fatality (million)	Wetlands (million)	Total Damages (million)
0%	1.0	7.5%	0.0	0.0%	$0	$0	$0	$0
5%	1.5	9.2%	0.0	0.0%	$0.0	$0.0	$0.0	$0.1
10%	1.6	9.9%	0.2	0.1%	$0.6	$0.4	$0.0	$1.3
15%	1.8	10.5%	0.8	0.6%	$3.4	$2.5	$0.0	$8.7
20%	1.9	11.2%	3.0	2.2%	$13.8	$10.1	$0.0	$24.7
25%	2.0	11.7%	7.5	5.5%	$35.5	$26.3	$0.0	$62.8
30%	2.1	12.0%	14.7	10.8%	$70.9	$51.7	$0.0	$124.3
35%	2.2	12.3%	25.4	18.7%	$117.5	$85.2	$0.0	$203.7
40%	2.3	12.6%	37.8	27.8%	$182.6	$131.1	$0.0	$315.4
45%	2.4	12.8%	54.8	40.2%	$262.9	$190.5	$0.0	$452.6
50%	2.5	13.0%	77.0	56.5%	$360.8	$266.1	$0.0	$631.9
55%	2.7	13.1%	105.1	77.1%	$501.4	$361.7	$0.0	$872.7
60%	2.8	13.3%	137.2	100.7%	$668.5	$493.8	$0.0	$1,173.4
65%	3.0	13.5%	182.8	134.2%	$883.5	$639.5	$0.0	$1,521.5
70%	3.1	13.6%	232.3	170.5%	$1,152.8	$847.6	$0.0	$1,997.1
75%	3.3	13.8%	308.3	226.3%	$1,517.2	$1,095.1	$0.0	$2,621.8
80%	3.5	13.9%	410.6	301.4%	$1,997.6	$1,455.1	$0.0	$3,460.0
85%	3.7	14.1%	554.7	407.2%	$2,792.9	$2,039.2	$0.0	$4,843.7
90%	3.9	14.3%	827.8	607.6%	$4,206.6	$3,053.3	$0.0	$7,241.5
95%	4.2	14.5%	1,532.7	1125.0%	$7,292.1	$5,307.7	$13.1	$12,618.0
100%	5.0	15.2%	23,415.0	17186.2%	$111,443.4	$86,982.0	$18.2	$198,436.5

The median of the distribution (i.e., the 50th percentile) is approximately $632 million. The mean of the distribution is $2.8 billion and represents the average of all possible future outcomes (including some with extremely high damages); the median represents the outcome that has an equal probability that the actual outcome will be higher or lower than the median. The 80th percentile value ($3.5 billion) indicates that there is a 20% chance that the damages could be higher than $3.5 billion. The 95th percentile value ($12.6 billion) indicates that there is a 5-percent chance that the damages could be higher than $12.6 billion.

Alternatively, in Appendix G ("Illustrative Approach to Higher-Consequence Event Damages") we present an approach to show higher-consequence damages using different assumptions. This

appendix contains the same basic method for estimating higher-consequence event damages as used in this analysis, employing a Monte Carlo simulation to run a large number of scenarios where the inputs are allowed to vary. As a basis of the approach in the appendix, there were approximately 5 million carloads of crude oil and ethanol shipped in Canada and the United States from 1995 – 2013, and over that time there was one higher-consequence event, the accident at Lac-Mégantic. PHMSA divides the total number of carloads shipped in US and Canada into the carloads we forecast to be shipped from 2015-2034 in the U.S. only: 26.2/5.3 = 4.94. Thus for this analysis, PHMSA estimates the number of higher consequence events that are likely to occur over the next 20 years in the absence of this rule at five (5) events. This approach resulted in a mean of $7.8 billion. It found at the 80th percentile a value of $11.1 billion, which indicates there is a 20-percent chance that the damages could be higher than $11.1 billion.

2. Total Estimated Damages

To estimate the benefits of this rulemaking PHMSA has estimated the effectiveness rates of several of the provisions. The effectiveness rates of the requirements are interdependent and some requirements, such as routing, can mitigate both the likelihood and the consequences of an accident. The table below presents the total undiscounted damage pool from which benefits are derived.

Table EB14: Expected Societal Damages

Year	LCE Damages	Mean HCE Damages	80th Percentile HCE Damages	95th Percentile HCE Damages
2015	$179,915,412	$140,250,000	$173,000,000	$630,900,000
2016	$176,427,442	$140,250,000	$173,000,000	$630,900,000
2017	$182,777,809	$140,250,000	$173,000,000	$630,900,000
2018	$196,334,749	$140,250,000	$173,000,000	$630,900,000
2019	$208,471,811	$140,250,000	$173,000,000	$630,900,000
2020	$221,509,522	$140,250,000	$173,000,000	$630,900,000
2021	$222,699,151	$140,250,000	$173,000,000	$630,900,000
2022	$223,063,891	$140,250,000	$173,000,000	$630,900,000
2023	$208,678,220	$140,250,000	$173,000,000	$630,900,000
2024	$223,774,639	$140,250,000	$173,000,000	$630,900,000
2025	$223,247,669	$140,250,000	$173,000,000	$630,900,000
2026	$219,084,383	$140,250,000	$173,000,000	$630,900,000
2027	$201,212,338	$140,250,000	$173,000,000	$630,900,000
2028	$212,100,606	$140,250,000	$173,000,000	$630,900,000
2029	$208,330,088	$140,250,000	$173,000,000	$630,900,000
2030	$204,293,980	$140,250,000	$173,000,000	$630,900,000
2031	$200,686,778	$140,250,000	$173,000,000	$630,900,000
2032	$196,924,311	$140,250,000	$173,000,000	$630,900,000
2033	$193,606,475	$140,250,000	$173,000,000	$630,900,000

2034	$190,456,652	$140,250,000	$173,000,000	$630,900,000
Total	$4,093,595,92	$2,805,000,000	$3,460,000,000	$12,618,000,000

3 Non-Quantified Benefits and Uncertainties

Non-Quantified Benefits

This section describes benefits of this rule that were unable to be quantified, but may be substantial. In addition, it describes the uncertainty surrounding many of the Agency's central estimates for monetizing societal damages. One of the primary unquantified benefits of this rule is harmonization with a corresponding Canadian tank car standard. Such harmonization facilitates international trade and cross border shipping of flammable liquids between these two neighboring countries. Without such harmonization, it is possible that crude oil would have to be transloaded from one rail car to another at the U.S. Canadian border, because the tank car containing the material failed to meet the tank car standard of the country to which the product was being shipped. Such trans-loading could impair economic activity, delay shipments of valuable commodities, and decrease the efficiency of the rail network in both countries. Such delays would impose substantial costs on the affected industries in both countries. The baseline for this analysis does not consider the effects of Canadian tank car regulations in the absence of new standards in the United States. In this way, the analysis under counts the benefit of harmonization that is a result of avoiding the aforementioned costs.

Uncertainties surrounding the Agency's Societal Damage Estimates

In this section the Agency describes uncertainties associated with the estimates it developed to monetize damages associated with crude and ethanol train derailments. We begin by discussing the findings of our literature review and data analysis of the costs imposed by crude and ethanol releases. Following that, we present evidence that the sample of events we used to estimate of the size of events/quantity released when a derailment occurs may not be representative of the size and impact of future events. Finally, we discuss uncertainty surrounding our central estimate of the number of high consequence events that may occur over the coming 20 years.

Damage estimates for crude oil and ethanol spills

The literature and information on the costs of crude and ethanol spills is fairly slight given that these incidents make the news on a regular basis. Comprehensive societal costs are especially difficult to obtain for rail incidents for the following reasons:

- Immediate response and clean-up are often the only cost elements reported when an incident occurs.
- Most research efforts have focused on crude oil maritime spills, which may have limited applicability to rail incidents;
- Studies of ethanol spill costs are scarce compared to studies on crude oil spills.
- Few studies examine spills in rail transport.

Spill Cost Literature Review

PHMSA identified and examined the studies[106] included in the RIA Appendix B under the Literature Review section to identify all categories of damage estimates for spills of crude oil and ethanol whether they were monetized or not (e.g., property damage, clean-up, emergency response, environmental damage and other costs). The table below reflects the consolidated categories of damages from the literature review for crude oil and ethanol (ethanol entries are shaded).

Study	Per gallon estimate $FY13	Oil Type	Mode	Response & clean-up costs	Lost Product/Lading	Environmental Damages	Socioeconomic Damages	Property damage (track, structures, and signals)	Evacuation costs	Incidental damages	Liability	Damaged tank cars damages	Train delay costs
Etkin (1999)	$326.00	Crude Oil	Spill response in the U.S.	√									
Marruffo (2012) [1]	$378.34	Crude	Rail	√									
Cohen (2010)	$892.29	Crude	Maritime	√	√	√	√			√	√		
Helton and Penn (1999)	$262.26	Crude / Fuel Oil	Intermodal	√	√	√	√	√	√	√	√		
Helton and Penn (1999) — Pipeline Incidents	$322.00	Crude / Fuel Oil	Pipelines	√	√	√	√	√	√	√	√		
U.S. Coast Guard (2011)	$271.00	Crude / Fuel Oil	Maritime	√		√	√			√	√		
U.S. Coast Guard (2010)	$385.00	Crude / Fuel Oil	Maritime	√	√	√	√	√		√	√		

[106] Excluded studies with cost estimates not based in U.S. dollar and impacts not in the U.S. (e.g., Vanem, Yamada, Kontovas, Montewka, Liu) and studies older than 1986.

Study	Per gallon estimate $FY13	Oil Type	Mode	Response & clean-up costs	Lost Product/Lading	Environmental Damages	Socioeconomic Damages	Property damage (track, structures, and signals)	Evacuation costs	Incidental damages	Liability	Damaged tank cars damages	Train delay costs
U.S. Coast Guard (2013)	$453.33	Crude / Fuel Oil	Maritime	√		√	√				√		
Etkin (2003) [2]	$633.71	Crude / Fuel Oil	Maritime	√		√	√						
Marruffo (2012) [1]	$8.22	Denatured Ethanol	Rail	√									
Saat et al. (2014) [3]	$144 - $225	Pure Ethanol	Rail	√					√		√		√

[1] Costs with labor associated with clean-up times only.
[2] Response costs: shoreline oil removal costs, on water mechanical recovery/on water dispersant response/in-situ burn costs, shore cleanup costs of oil not burned, mobilization, and protective booming/sensitive site protective booming.
[3] Yields 225/gallon when considering 56% increase in consequence costs due to legal settlement expenses.

From the table above we ascertain that more categories of damages were available and used to estimate total damages for crude oil spills than for ethanol spills. However, in some of the crude oil spills related studies certain types of damage categories were not included as seen in the table above (e.g., Etkin, Marruffo). Helton and Penn are the only authors to look at spills associated with multiple transport modes. Helton and Penn do not include and rail incidents but include 5 pipeline incidents. The average cost per gallon for those 5 pipeline incidents is $322/gallon which is higher than the $218 the average cost per gallon for all ocean/maritime incidents[107] they looked at, if the Exxon Valdez incident (an extreme outlier on both cost per gallon and total spill volume) is excluded. Incorporating all non-maritime incidents in Helton and Penn into the average with the pipeline incidents provides an estimate that is virtually identical to the maritime incidents if Exxon Valdez is excluded. This finding provides some evidence that land-based spills may meet or even exceed maritime spills in average cost per gallon. However, given that Helton and Penn are careful to note that their estimates are not derived from spills that are statistically representative of all incidents, this finding should be treated with some degree of caution.

[107] Includes Exxon Valdez.

Given the comparative findings from Helton and Penn, it may be useful to consider whether costs estimated from maritime spills may be applicable to other land-based modes. The average for the three USCG estimates is $370/gallon spilled, but they range from approximately $270 to over $400. Thus, there is evidence that the true cost to society from crude oil spills may be 50 percent, or even double, the Agency's central estimate.

The resources available for estimating damages with ethanol spills are scarce. While the reports available are associated with rail incidents, from the table above we gather that the NTSB reports do not include many categories of damages (e.g., environmental damages to natural resources, socioeconomic damages, network delays, evacuation, and liability). The model described in Marruffo (2012) model is used to predict the relative impact of crude oil or ethanol released from railroad-tank car accidents on soil and groundwater contamination and cleanup times, but no monetized costs are presented.

Saat et al (2014) describes a quantitative, environmental risk analysis of rail transportation of a group of light, non-aqueous phase liquid chemicals including ethanol. The authors developed probabilistic estimates of exposure to different spill scenarios along the N. American rail network. The Agency derived an estimated cost per gallon from this study of $144. The environmental (i.e. soil and groundwater) consequence model in which the clean-up cost and total shipment distance are most significant risk factors, estimating clean-up, evacuation and delays damages. The authors estimate a 56% increase in total consequence cost estimates due to legal settlement expenses. Moreover, the environmental consequence model used in this study focuses on soil and groundwater cleanup. The authors mention that the environmental cost would increase when considering damages to natural resources such as surface water bodies and other hazards.

In addition, this study considers pure ethanol, rather than ethanol mixed with denaturant. Most ethanol transported by rail is mixed with 5% or more denaturant, usually either gasoline or diesel fuel. The costs to clean up this chemical mixture may exceed those to clean up pure ethanol, so applying the cost per gallon obtained from this study to rail incidents may underestimate the costs associated with these incidents since denatured ethanol may be substantially more costly to clean up than pure ethanol.

The weighted average of the per gallon estimates from all the listed literature is between $ 407 to $415[108] per gallon spilled of crude oil or ethanol. In addition, it is unlikely that any of these estimates capture the full comprehensive societal damages that result from these incidents.

[108] If we average all the per gallon estimates across all the studies from the literature review table we get $407 per gallon when calculating the average with the $144 per gallon from the Saat study, or $415 per gallon when calculating the average with the $225 per gallon from the Saat study.

The USCG estimates as shown in this table are the most complete and current estimates available on the total costs crude oils spills impose on society. Even these cost estimates may undervalue the damages imposed as they use liability claims and NRC estimates as a proxy for environmental damages. In many cases, liability claims may undervalue the full damage imposed on third parties by oil spills – some individual with valid claims may not come forth, and some damaged parties may not be able to prove damages and hence make claims.

As Helton and Penn note in their study:

> *"Complete cost information was not possible to obtain since many categories of cost are not routinely made public. As a result, we excluded spill incidents with minimal cost information. Even among the included cases (see Table 1), cost information was not complete. When cost estimates are reported, they should be considered partial and spill volumes should be viewed with some skepticism."*

Because the costs associated with these spills are hard to obtain and quantify, any source of data is likely to underestimate total spill costs to a greater or lesser extent. The hedonic studies by Hansen et al and Simons et al, see literature listed in Appendix B, in addition to contingent valuation studies by Carson et al and other authors provide evidence of costs imposed by these incidents that are difficult to estimate, but may be substantial. No public reporting by entities responsible for spills is likely to capture the full non-market impacts of a spill. Even careful attempts to quantify all costs associated with spills may come up short.

Data from Agency Sources

PHMSA attempts to collect comprehensive incident costs for both hazardous liquid pipeline spills and spills involving other transportation modes. The Agency consulted EPA for estimates of the costs imposed by spills regulated by EPA, but no reliable estimates were obtained. The EPA has produced past estimates using pipelines data, an indication that the pipeline data may be the most reliable and high quality data available from a public database. The values obtained from the pipelines data were the primary estimate for crude oil costs used by the Agency, but the Agency notes that the literature review conducted resulted in estimates much higher than this figure. The Agency's central estimate should therefore be considered fairly conservative.

Incident Severity

There is reason to believe that the Agency's estimate for incident severity may be low, because there is evidence that the number of flammable liquid cars per train has been growing over the past decade and may continue to grow. FRA analysis of the Waybill sample shows the following growth in the number of crude and ethanol cars per train for all trains hauling 1 or more carload of crude or ethanol.

Table EB15: Incident Severity by Commodity		
Year	**Crude**	**Ethanol**
2005	10.45	5.50
2006	9.86	6.44
2007	11.15	11.70
2008	7.56	17.16
2009	8.04	27.75
2010	61.26	34.94
2011	49.90	38.60
2012	65.77	41.39
2013	77.13	46.19

As can be seen the number of crude or ethanol cars per train has increased significantly over the past decade for both commodities. Below is a comparison between the historical number of hazmat tank cars in a train from the waybill data and the accident data the Agency based its low consequence damages on. (33 ethanol accidents and 13 crude oil accidents):

Table EB16: Historical Incident Severity		
Average Number of Hazmat Cars	**Ethanol**	**Crude**
Waybill data 2013	46	77
Accidents data	38	51
Percentage increase waybill data to accidents data	22%	51%

Ethanol concentration (cars per train) has grown modestly compared to the average for the incidents the Agency used to estimate damages. For crude oil trains, the increase in car-concentration has been much more dramatic. FRA experts believe that further increases in the concentration of cars on crude oil trains is likely, but expect that ethanol consists will resemble the data from 2013 going forward. As can be seen in the table, ethanol trains are likely to contain 22 percent more cars than the Agency's sample of derailed trains contained, on average, and 51 percent more crude oil cars than the Agency's derailment sample. Further concentration of crude oil is likely, but neither PHMSA nor FRA can say where the cars per train figure will stabilize. Accident severity may be associated with an increase in the number of cars hauling hazardous material because the more hazmat cars on the train, the more likely that a higher number of hazmat cars will be involved in the derailment and hence at risk of puncture and release of material.

While the concentration of crude oil and ethanol carloads into unit trains will tend to increase the expected damages of a derailment, it is likely that there will be fewer derailments involving crude oil and ethanol, because there will be fewer trains carrying crude oil and ethanol.

PHMSA and FRA do not have evidence to show that the increase in expected severity will be larger than the decrease in derailment rate that is expected to result from continued concentration of crude oil and ethanol tank cars into unit trains. However, to the extent that the severity rises

more than the derailment rate falls, consolidation of tank cars into unit train service is a potential source of undercounted benefits.

Likelihood and Number of HCEs

One way to predict the number of accidents that will occur in a given period is to look at the past rate of accidents per unit of volume (train miles, vehicle miles traveled, carloads shipped, etc.) and project those incidents forward based on expected future volume. Thus if 1 car crash occurs per 100,000 vehicle miles travelled, one can get an estimate for car crashes going forward if one has a forecast of future traffic volumes. Given their uncertainty and extenuating contributing factors associated with high consequence events, applying such a rate to such events may not produce an accurate forecast. On the other hand, such an exercise can be illustrative of potential risk.

We note that one such event has occurred in the North American safety record – the tragic event at Lac-Mégantic, Quebec in July of 2013, At the time of that event, approximately 5 million carloads of crude and ethanol had been shipped over the course of the time period from 2000-2013 in the U.S. and Canada. Prior to 2000, the quantities of both commodities shipped by rail were fairly negligible. As presented in the Benefits Section in the RIA, we forecast 25 million carloads of crude and ethanol to be shipped over the next 20 years. At a rate of 1 event every 5 million carloads, approximately 5 high consequence events could be expected over this time period. We also note that our Monte Carlo simulation produces results that indicate the possibility of a single event that may exceed Lac-Mégantic in total cost by an order of magnitude or more. Mitigating or preventing one such event might produce benefits that exceed the cost of this rule.

In addition, 5 high consequence events exceed the Agency's best estimate for the likely number of HCEs by 3 events, and is slightly higher than the number of events in the 95th percentile of the Monte Carlo simulation results. These events may occur with less frequency than a crude exposure estimate, such as events per million carloads, produces. However, the fact that one such event occurred so soon after the advent of high volume rail shipments of crude suggests the possibility that additional HCEs may occur. If those events are particularly severe or numerous, the potential damages inflicted on society could be tens of billions of dollars. Mitigating or preventing these events could produce very large societal benefits.

Additionally PHMSA used the following methodology to explore its data to determine the number of potential high consequence events (HCE) in the next 20 years. This methodology applies a derailment forecast to the network to identify how many derailments are likely to occur in densely populated areas; it does not address a high consequence environmental damage event. In order to explore a reasonable number of events, a few baseline figures are necessary. One such event has occurred in North America, involving derailment of a crude oil train in the town of Lac-Mégantic. Lac-Mégantic has a population density of roughly 700 people per square mile, which equates to about 136 people per half-square km. We use population per half square km to approximate the people at risk in the event of a derailment that results in a fire by a crude or ethanol train.

PHMSA ran a different 10,000 iteration Monte Carlo simulation modeling a single derailment placed on the HHFT network to identify what percentage of derailments might occur at various population densities along the rail network. For each iteration, a single derailment was allowed to randomly be placed in a location along the crude oil and ethanol rail network, with two assumptions.

- First, the probability of an accident occurring along a rail link is proportional to the rail link length under the reasonable assumption that a longer link would have a higher likelihood of derailment.
- Secondly, the probability of an accident occurring in a HTUA versus the rest of the HHFT network is based on the tons transported on the fuel network which represents a proxy for the usage of the rail track.

The table below presents population in a half square KM adjacent to the track in the first column, and the percentage of times the 10,000 iterations placed the derailment on a link with that population density in the second column.

Table EB17: Population Density

Population per 5 Sq Mile	Frequency	Percent
0-100	5551	56%
100-200	1172	12%
200-300	710	7%
300-400	460	5%
400-500	381	4%
500-700	491	5%
700-900	243	2%
900-1000	127	1%
1000-1200	159	2%
1200-1400	126	1%
1400-1500	46	0%
1500-1700	84	1%
1700-2000	84	1%
2000-24227	366	4%

The derailment occurs in places with 200 or more people per half-square km roughly 33 percent of the time. This population density is greater than the population density in the location where the one HCE on the North American public safety record occurred. PHMSA predicts 278 derailments to occur over the coming 20 years. Based on historic derailment data, we expect one carload or more of flammable liquid to ignite and cause a fire on approximately 30.4 percent of these derailments, or about 85 derailments. 30.4 is the percentage of derailments from 2006 – 2014 that resulted in release of flammable liquid that ignited to cause a fire (14 of 46 derailments). The Agency believes that any event that results in the ignition of flammable liquid released during a derailment could become an HCE in the right circumstances. Based on the same data, we could expect approximately 13 percent of these derailments to involve a fire with the release of 230,000 or more gallons of product, or approximately 36 derailments. These would be large releases of a high volume of flammable liquids, resulting in a fire which could spread

over a fairly large area and burn for several hours or days. Based on the results of the simulation, 33 percent of the 36 derailments involving a fire would occur in areas with significant population at risk, 36 × 0.33 = 12 derailments involving a fire and release of a large quantity of flammable liquid in a populated area.

The 12 higher consequence events estimate showing derailments likely to occur in densely populated areas coupled with the most recent Lac-Mégantic accident damage estimate of $1.5 billion[109] in clean-up costs, the value of lost business activity, temporary unemployment of those working at the businesses destroyed, reconstruction costs and other non-fatality damage costs suggest that PHMSA's total damage estimates are very conservative.

4. Cost Uncertainties

In the following sections we present the estimated costs and benefits of the various provisions required by the accompanying Final Rule. It is important to note areas where there are uncertainties regarding the cost estimates described below, and where costs may be over or underestimated. The Table below presents some areas where cost uncertainties exist, and whether the estimates used by the Agency are likely to result in overestimation or underestimation of costs.

Table EB 18: Cost Uncertainties

Cost Area	Direction of Uncertainty		Brief Explanation of cause of uncertainty
	Underestimation	Overestimation	
Number of entities affected by Routing Requirements		X	The Agency believes that the number of smaller railroads (class 3) accounted for in the Routing Analysis (160) below may be significantly overestimated. Examination of the Waybill data indicates that fewer than half the number of small railroads used in the Agency's analysis may in fact haul crude or ethanol. The Agency did not rely on the Waybill data because it is possible that it would underrepresent small carriers, but notes that the actual

[109] The Canadian Government representatives' unofficial estimate. Another source cites the total cost for rebuilding the broken town of Lac-Megantic of $2.7 billion over the next decade, which is four times in size the damage estimate used in PHMSA's analysis: http://www.pressherald.com/2014/04/17/after-end-of-the-world-explosion-lac-megantic-aims-to-rebuild/

Table EB 18: Cost Uncertainties			
Cost Area	**Direction of Uncertainty**		**Brief Explanation of cause of uncertainty**
	Underestimation	**Overestimation**	
			number is likely substantially fewer than 160.
Cost of retiring cars from crude and ethanol service		X	The Agency assumes that cars retired from crude and ethanol service are scrapped, rather than repurposed to other rail service. If demand exists for these cars to haul other commodities, the cost of retiring them from crude and ethanol service would be much lower than the cost of scrapping the cars.
Impact on cars hauling other flammable liquids	X		Based on a review of Waybill Data, the Agency has assumed that only a small number of the cars hauling flammable liquids other than crude and ethanol would have to be retrofitted, because few of these commodities are shipped in carload quantities large enough to meet the definition of a HHFT. If future haul patterns differ from historical patterns and a significant number of the cars used to haul other flammable liquids do in fact have to be retrofit to comply with the requirements of this rule, the Agency may have underestimated the costs associated with this provision of the rule.
ECP brakes assumed to need overlays		X	The Agency has assumed that all cars equipped with ECP brakes would require overlay systems so that they could be used in non-ECP mode. However, cars kept in a unit train dedicated to crude or ethanol service would not necessarily need an overlay system, because so long as the cars are kept together in a single train, they could always operate in ECP mode. Thus, by assuming that all cars equipped with ECP braking would have overlay systems, when some may not, the Agency may have overestimated costs.
Out of service times		X	The Agency has assumed that all cars requiring retrofits would be out of service for 8 – 12 weeks while being retrofit. It is likely that, given the volume of cars involved, that retrofitting

Table EB 18: Cost Uncertainties			
Cost Area	**Direction of Uncertainty**		**Brief Explanation of cause of uncertainty**
	Underestimation	**Overestimation**	
			cars will be streamlined and the total out of service time may be reduced relative to the Agency's estimate. One way that owners and lessors may streamline retrofitting is by aligning a given tank car's retrofit with requalification, which is already required. To the extent that owners and lessors are able to do this, the analysis overestimates costs by including out-of-service time that would already have been needed for requalification.
ECP car reductions		X	The ECP efficiencies allow for a reduction in the number of tank cars required. ECP trains have faster cycle times as they can avoid some brake inspections, can have higher brake ratios, and can maintain ideal track speed. This allows fewer trains to provide the same level of production. In our analysis we estimated that 4,835 fewer new tank cars would not need to be purchased due to the ECP efficiencies. Although a new tank car (Jacketed CPC-1232) costs about $127,000 we only used the incremental difference, $3,000, of the DOT 177 to estimate the cost savings. This provided us a cost saving of $14.5 million. If we had used the true cost of a new Jacketed CPC-1232 tank car the total cost savings would have been $614.0 million.
Speed restriction network effects	X		The Agency estimated the costs from slowing HHFTs to 40 mph in HTUAs, which is based on analysis of a rail subdivision to calculate the costs of slowing down other types of trains on that subdivision. The results of this analysis were extrapolated to the crude oil and ethanol rail corridors, but the analysis does not take into account the possibility that some rail traffic that is affected by the speed limit would be diverted onto trucks or other modes of transit. The analysis also does not account for the possibility of slowing down the network aside from the crude oil and ethanol corridors.

In addition to the above cost uncertainties, at least one rail company – BNSF – has committed to phasing out DOT-111s from shale crude oil service within a year, and transitioning from unimproved CPC 1232 cars used in this service within three years. Voluntary measures taken by companies would reduce the impacts of this rule. Voluntary safety actions and investments also suggest rail companies see potential business benefits by reducing risks and consequences associated with HHFT transport.

VIII. Cost Analysis

In each requirement area the "Actions" are derived from the final rule. The alternatives considered by PHMSA are discussed separately and include a review of the costs for each proposed requirement. PHMSA regards the cost estimates as conservative. In all likelihood, the combined forces of the market and technology may result in costs lower than those forecasted.

Below are some of the revisions made when developing the costs of each alternative under the requirement areas:

1) Increase the number of small railroads impacted by the new routing requirements
2) Adopt separate standards for new tank car construction requirements consistent with Option 2 of the NPRM except for the braking component and retrofit requirements for existing tank cars in accordance with Option 3 from the NPRM (excluding top fittings protection and steel grade)
3) Revise tank-car, retrofit timeline based on comments from RSI and others
4) Revise several tank car costs and include costs for truck upgrades
5) Revise and update the tank car fleet based on expected 2015 deliveries and consultations with Transport Canada
6) Limit the ECP braking requirements to trains composed of 70 or more cars of a Class 3 Flammable liquid travelling at a speed of greater than 30 mph
7) Adjust the estimated cost to equip tank cars with ECP brakes

Update number of offerors of unrefined petroleum-based products based on a recent review of active PHMSA registrations

IX. Final Rule Requirement Areas

The final rule and this RIA have six separate requirement areas:

1) Tank Car Specifications
2) Advanced Brake Signal Propagation Systems
3) Speed Restrictions
4) Routing and Notification Requirements
5) Classification of Unrefined Petroleum-Based Products

A. Requirement Area 1 – Rail Routing

Final Action: PHMSA is requiring the expansion of Hazardous Materials Route Planning and Selection.

PHMSA is requiring rail carriers develop and implement a plan that will result in the use of a safer and more secure route for HHFTs, defined as trains with 20 or more tank cars in a block or 35 or more tank cars throughout the train consist loaded with any Class 3 flammable liquids.

1. Determination of Need

There has been considerable public and Congressional interest in the safe and secure rail routing of security-sensitive hazardous materials. In 2008, PHMSA, in coordination with the FRA and the Transportation Security Administration (TSA), issued a final rule requiring rail carriers compile annual data on certain shipments of explosive, toxic by inhalation (TIH or PIH), and Class 7 (radioactive) materials. The rule also required rail carriers to use the data to analyze safety and security risks along rail routes where those materials are transported; assess alternative routing options; and make routing decisions based on those assessments (73 FR 20752). These requirements were codified at 49 CFR 172.820.

The 2008 rule also requires rail carriers transporting "security sensitive materials" to select the safest and most secure route to be used in transporting those materials, based on the carrier's analysis of the safety and security risks on primary and alternate transportation routes over which the carrier has authority to operate.

The NTSB report of January 23, 2014 states that at a minimum, the route assessments, alternative route analysis, and route selection requirements should be extended to *key trains* transporting large volumes of flammable liquids. NTSB Recommendation R-14-4 recommends that PHMSA should:

Work with the Federal Railroad Administration to expand hazardous materials route planning and selection requirements for railroads under Title 49 Code of Federal Regulations 172.820 to include *key trains* transporting flammable liquids as defined by the Association of American Railroads Circular No. OT-55-N and, where technically feasible, require rerouting to avoid transportation of such hazardous materials through populated and other sensitive areas.

Although Class I rail carriers committed to voluntarily apply routing requirements to trains carrying 20 carloads or more of crude oil as a result of the Secretary's Call-to-Action:

1) The voluntary actions do not extend beyond Class I railroads;
2) The voluntary actions do not apply to all HHFTs;
3) The final routing requirements would provide a check on higher risk routes or companies; and
4) The final routing requirements would ensure that rail carriers continue their voluntary actions in the future.

2. Action by the United States and Canada

U.S. Action

In the NPRM, PHMSA proposed to require rail carriers develop and implement a plan that will result in the use of a safer and more secure route for certain trains transporting high-hazard flammable liquids. Specifically, PHMSA proposed to require rail carriers to comply with the additional safety and security planning requirements prescribed in § 172.820, for HHFTs. Specifically, this would require carriers to perform a routing analysis that considers 27 safety and security factors. The carrier must then select a route based on findings of the route analysis.

In November 26, 2008 PHMSA issued a final rule that required railroads to select a practicable route posing the least overall safety and security risk to transport security sensitive hazardous materials (Docket HM-232E: 73 FR 72182). The final rule implemented regulations requiring railroads to compile annual data of current shipment of explosives, Poisonous by Inhalation (PIH) and Class 7 (radioactive) materials.

The key provisions of the 2008 final rule are:

1) Rail carriers transporting hazardous materials that the Department of Homeland Security deems security-sensitive must annually compile information and data on the commodities transported, including the transportation routes over which these commodities are transported.

2) Rail carriers transporting security-sensitive materials must use the data they compile to annually analyze the safety and security risks for the route(s) used to transport a security-sensitive material. In performing this analysis, the rail carrier must seek relevant information from State, local, and Native American Indian tribal officials, as appropriate, regarding security risks to high-consequence targets and the communities' emergency response capability, along, or in proximity to, the route(s) utilized. Rail carriers also are required to use the data to analyze the safety and security of all practicable alternative routes which the carrier is authorized to use. When determining practicable alternative routes, the rail carrier must consider the use of interchange agreements with other rail carriers and the potential economic effects of using the alternative route. The railroad must also consider any remediation measures implemented on a route. Using this process, the carrier must at least annually review and select the practicable route posing the least risk to safety and security. The initial analysis and route selection must include a comprehensive review of a carrier's entire system. Subsequent analysis and route selection determinations must include:
    - A comprehensive, system-wide review of all operational changes,
    - Infrastructure modifications,
    - Traffic adjustments,
    - Countermeasures,
    - Changes in the nature of high-consequence targets located along, or in proximity to, the route,

- Changes to community response capabilities, or other changes affecting the safety or security of the movements of the security-sensitive materials that were implemented during the calendar year.

Rail carriers are required to maintain a copy (or electronic image thereof) of the data collected and the routing analysis for at least two years and make the records available upon request to authorized officials of the Departments of Transportation and Homeland Security.

3) Rail carriers are required to specifically address the security risks associated with security-sensitive shipments delayed in transit or temporarily stored in transit as part of their security plans.

4) Rail carriers transporting security-sensitive materials are required to notify consignees if there is a significant unplanned delay affecting the delivery of the materials.

5) Rail carriers are required to conduct visual security inspections at ground level of rail cars containing hazardous materials to inspect for signs of tampering or the introduction of an improvised explosive device.

This rule addressed both safety and security concerns associated with the transportation of certain types of hazardous materials, particularly PIH materials. One part of the accompanying final rule would apply these route analysis, rerouting, and safety and security requirements to HHFTs. Because PHMSA believes it is rare that commodities other than crude oil and ethanol are shipped in HHFTs, PHMSA restricted the analysis to crude oil and ethanol, though it is possible that small quantities of other flammable liquids could be attached to such trains.

AAR Recommended Railroad Operating Practices for Transportation of Hazardous Materials

At the time that the rail routing rule was promulgated, the rail industry developed a detailed protocol on recommended railroad operating practices for the transportation of hazardous materials. The AAR issued Circular No. OT-55-I (OT-55-I), on August 26, 2005. OT-55-I detailed railroad operating practices for:

1) Designating trains as *key trains* that contain
    a) Five tank car loads or more of PIH materials,
    b) 20 car loads or intermodal portable tank loads of a combination of PIH, flammable gas, Class 1.1 or 1.2 explosives, and environmentally sensitive chemicals, or
    c) One or more car loads of spent nuclear fuel or high-level radioactive waste;
2) Designating operating speed and equipment restrictions for key trains;
3) Designating *key routes* for *key trains*, and setting standards for track inspection and wayside defect detectors;
4) Yard operating practices for handling placarded tank cars;
5) Storage, loading, unloading and handling of loaded tank cars;
6) Assisting communities with emergency response training and information;
7) Shipper notification procedures; and

8) Handling of time-sensitive materials.

These recommended practices were originally implemented by all of the Class I railroad operating in the United States; short line railroads later joined as signatories.

OT-55-I defined a *key route* as:

> *Any track with a combination of 10,000 car loads or intermodal portable tank loads of hazardous materials, or a combination of 4,000 car loadings of PIH (Hazard Zone A, B, C, or D), anhydrous ammonia, flammable gas, Class I.1 or 1.2 explosives, environmentally sensitive chemicals, Spent Nuclear Fuel (SNF), and High-Level Radioactive Waste (HLRW) over a period of one year.*

Any route defined by a railroad as a *key route* was required to meet the standards contained in OT-55-I. For example, wayside defective wheel bearing detectors should be placed at a maximum of 40 miles apart, or an equivalent level of protection may be installed based on improvements in technology. Main track on *key routes* should be inspected by rail defect detection and track geometry inspection cars or any equivalent level of inspection at least twice each year. Sidings on *key routes* should be inspected at least once a year; and main track and sidings should have periodic track inspections that will identify cracks or breaks in joint bars. Further, any track that is used for meeting and passing *key trains* should be FRA Class II track or higher. If a meet or pass must occur on less than Class II track due to an emergency, one of the trains should be stopped before the other train passes. The rail routing enhancements to the existing security rule partly reflected the recommended practices mentioned above, which were already in wide use across the rail industry.

On August 5, 2013 the AAR released a new Circular OT-55-N which expanded the definition of *key trains* to include any train with 20 or more carloads of any hazardous material.[110] That circular placed the following restrictions on such "key trains" which would include any train with 20 or more cars of flammable liquids:

1) Maximum speed - *Key Train* - 50 MPH
2) Unless siding or auxiliary track meets FRA Class II standards, a *key train* will hold main track at meeting or passing points, when practicable.
3) Only cars equipped with roller bearings will be allowed in a *key train*.
4) If a defect in a *key train* bearing is reported by a wayside detector, but a visual inspection fails to confirm evidence of a defect, the train will not exceed 30 mph until it has passed over the next wayside detector or delivered to a terminal for a mechanical inspection. If

[110] Available online at http://www.boe.aar.com/CPC-1258%20OT-55-N%208-5-13.pdf

the same car again sets off the next detector or is found to be defective, it must be set out from the train.

In addition to applying a 50-mph speed limit to HHFTs, which is already in effect due to universal compliance with Circular OT-55-N, this final rule would incorporate the route analysis and rerouting requirements, as well as the safety and security requirements described above as part of HM-232E to HHFTs. The cost of route analysis and rerouting for PIH trains was considered in 2008 in the regulatory evaluation accompanying the final rule.

Canadian Action

On April 23, 2014, Transport Canada issued an Emergency Directive requiring all companies to complete a risk assessment by October 23, 2014. The risk assessment must determine the level of risk associated with each "*key route* over which a *key train* is operated by the company." Specifically, the risk assessment must:

1) Identify safety and security risks associated with that route, including the volume of goods moved on that route, the class of track on that route, the maintenance schedule of the track on that route, the curvature of the track on that route, the environmentally sensitive or significant areas along that route, the population density along that route, emergency response capability along that route and the areas of high consequence along the route;
2) Identify and compare alternative routes for safety and security; and
3) Factor potential or future railway operational changes such as new customers moving good subject to an Emergency Response Assistance Plan under the Transportation of Dangerous Goods Act or municipal changes due to population growth, for routing restrictions.

3. Specific Comments

In general, the comments received regarding the proposed routing requirements in the NPRM are regarding the impact of the definition of HHFTs. The American Short Line and Regional Railroad Association (ASLRRA) commented that the number of short rail line carriers that would be affected by this final rule should be at least 160 instead of 64 as estimated in initial RIA. PHMSA revised the estimated costs with the routing requirements in this rule to account for the updated number of short line carriers impacted by the requirement.

4. Rail Routing Alternatives

Status Quo

Route planning and route selection provisions currently required for explosive, PIH, or Class 7 (radioactive) materials are not required for HHFTs. If the final rule is not adopted, railroads would not be required to conduct route risk analysis nor are they required to reroute shipments over lower-risk routes. Specific identified criteria for the route and alternate route analyses may not be uniformly considered by all railroads, and written analyses of primary and alternate routes

including safety and security risks would not be required. Due to the definition of an HHFT we expect the impact is on HHFTs of crude oil and ethanol. While the railroads are expected to continue voluntarily implementing these measures for crude oil, they have not made a similar commitment for ethanol trains (though PHMSA believes some of them may do so). The costs to society, the government, and the rail industry of an accident involving large shipments of flammable liquids are high. If no action is taken, the threat of catastrophic accidents in large populated areas or other sensitive environments will continue.

Apply Routing to HHFTs

This alternative would apply safety and security routing assessments and rerouting to HHFTs. Railroads would be required to assess current routing of these trains as well as practical alternative routes. Railroads would have to choose the lowest risk practical route to move HHFTs. This alternative focuses the routing requirements on the flammable liquid shipments that pose the greatest risk to public safety.

5. Rail Routing Requirement Cost-Benefit Analysis

As discussed above, on February 21, 2014 the AAR committed to apply the existing routing requirements described above to unit trains with 20 or more carloads of crude oil. Class I railroads have signed on to this agreement, and will voluntarily apply routing requirements to trains carrying 20 carloads or more of crude oil. Since the Class II and III railroads have not signed on to this commitment, the short lines would not voluntarily apply the route analysis requirements to HHFTs, and hence would bear costs associated with analyzing their networks, identifying alternative routes, and rerouting shipments along lower-risk routes where practicable. However, in practice, Class II and III railroads would bear little, if any, cost because much of the work to identify safest routes has already been done in compliance with the previous regulation. In addition, most short line railroads operate along a small number of corridors – often only one – and would therefore not have practical alternative routes for HHFTs. These limited networks also mean that analyzing primary and alternative routes would be a minor task with modest cost for Class III railroads. As a result, we assume that the costs associated with this requirement would modest for Class II and III railroads.

The final rule applies routing requirements to trains with 20 tank cars in a block or 35 tank cars throughout the train consist loaded with any Class 3 flammable liquids. The AAR voluntary commitment only covers crude oil shipments, which leaves open the question of whether any additional burden would be imposed on the requirement to apply route analysis and rerouting to all HHFTs. PHMSA believes that the cost of covering HHFTs containing all flammable liquids, given that railroads are already analyzing their networks to identify lower risk routes for PIH and crude oil shipments, would be minimal. The requirement imposed by these regulations is to analyze the entire network to identify lower risk routes. As described in the HM-232E RIA, the per-carrier costs associated with this analysis depend on the size of a carrier's network, which determined the number of primary and alternative routes that must be analyzed. The total costs are influenced by the number of carriers affected – i.e., the number of carriers that haul crude oil and ethanol.

PHMSA believes that all Class I railroads who haul ethanol also haul these other high-hazard materials. As a result, the inclusion of HHFTs containing ethanol would not result in an increase in the number of routes that would have to be analyzed, nor the number of carriers who would have to analyze these routes to identify lower-risk alternatives. Since these networks are already being analyzed to identify lower risk routes for PIH and HHFTs containing crude oil, we believe that only a minimal amount of additional work, resources, or costs would be imposed by the additional requirement of covering high-hazard ethanol trains under these requirements.

Routing Requirement Costs

Costs associated with the routing requirements of this final rule include costs for collecting and retaining data and performing the mandated route safety and security analysis if not already in place. When necessary, off-the-shelf software is available to perform routing assessments. There could be additional fuel, maintenance, or shipment time if the analysis reveals a need to reroute high-hazard flammable liquid trains that result in increased mileage.

The costs associated with gathering data and analyzing that data using these new requirements are modest. Rail carriers and shippers may incur costs associated with rerouting shipments or mitigating safety and security vulnerabilities identified because of their route analyses. However, because this final rule builds on the current route evaluation and routing practices already in place for most, if not all, rail carriers that transport the types of hazardous materials covered, we do not expect rail carriers to incur significant costs associated with rerouting. The rail carriers already conduct route analyses and re-routing that provides results in line with what this final rule is making a standard practice (in accordance with AAR Circular OT-55-N).

The analysis for the HM-232E final rule attributed minimal costs for rerouting shipments to lower risk routes. At the time of publication, PHMSA asked for comment on whether rerouting shipments covered under the new final rule would impose an undue burden on the industry, and did not receive any adverse comments on the issue. As a result, PHMSA did not modify the assumption that rerouting would impose little if any cost on shippers or rail carriers. PHMSA and FRA make the same assumption for HHFTs in this final RIA.

There is evidence that this assumption is reasonable. First, the industry has voluntarily agreed to apply these same routing requirements to HHFTs containing crude oil, which implies that rerouting does not impose a significant burden or at least that the burden does not significantly exceed the carriers' own expected safety benefits from rerouting. Second, no rerouting would be required if no practical alternative route is available. As noted above, the industry has not expressed concern on this issue in past rulemaking actions. Thirdly, the routing provisions require the rail carriers to consider various factors when selecting route including length of trip. As trip length increases, the exposure to the risk of derailment increases. A shorter route is a safer route, all other things held equal. Rail carriers are required to consider these factors when routing the types of hazardous materials covered under the previous rulemaking, and make the results of their routing plans available for review. In reviewing these plans, PHMSA and FRA observed little if any increase in total shipment mileage because of complying with this requirement.

Therefore, it seems unlikely that mileage or shipping time increases would impose significant costs if routing requirements were applied to HHFTs containing ethanol. Finally, a rail simulation study found that substantial risk reduction (reductions in either the likelihood or severity of an event) could be achieved through rerouting with very modest increases in shipment mileage. As a result, PHMSA did not attribute costs for rerouting of ethanol shipments in this analysis.[111]

In 2008, PHMSA estimated the cost of compliance with the routing final rule based on the size of the company. In this analysis, Class I and regional railroads (Class II) were considered "large railroads" and Class III railroads are considered "small railroads." There are seven Class I railroads, 10 regional railroads, and more than 500 small railroads.[112] Based on that information PHMSA estimated that only 64 short haul rail carriers haul shipments of flammable liquids large enough to fall under the final rule. ASLRRA commented that there would be at least 160 short haul rail carriers instead. Based on this comment PHMSA revised the estimated costs with the routing requirements in this rule accordingly. Table R1 displays the number and size of rail carriers subject to additional routing requirements in the final rule.

Table R1: Rail Carriers Subject to Routing Requirements

Number of Affected Rail Carriers by Size
17 Large Rail Carriers
160 Small Rail Carriers
177 Total Rail Carriers

As a result of the February 21, 2014, commitment to apply routing requirements to trains with 20 or more carloads of crude oil, no costs are attributed to Class I railroads for developing routing plans for crude oil shipments. PHMSA believes Class I railroads may already be applying route analysis to ethanol shipments despite the absence of a requirement or commitment to do so. Even if this is not the case, we believe there would be a minimal cost to add ethanol to routing analysis for crude oil. As a result, we attribute no additional cost to Class I railroads to comply with these requirements.

Since the Class II and III railroads have not signed on to this commitment, we assume Class II and III railroads would not voluntarily apply the route analysis requirements to HHFTs, and hence would bear costs associated with analyzing their networks, identifying alternative routes, and rerouting shipments along lower-risk routes where practicable. In practice, Class II and III railroads would bear modest costs because much of the work to identify safest routes has already

[111] Glickman, Erkut, and Zschocke. 2007. The cost and risk impacts of rerouting railroad shipments of hazardous materials. Accident Analysis and Prevention. 39. 1015-1025.

[112] 'Railroad Facts', Association of American Railroads, 2004, p.3.

been done in compliance with the previous regulation. In addition, most short line railroads operate along a small number of corridors – often only one – and would therefore not have practical alternative routes for HHFTs. These limited networks also mean that analyzing primary and alternative routes would be a minor task.

The labor rate used to estimate costs was $38.17. This labor rate is a combination of two employee groups listed in the Bureau of Labor Statistics May 2013 Industry-Specific Occupational Employment and Wage Estimates.[113] The two employee groups used were NAICS 482000-Rail Transportation occupational code 11-0000 "Management Occupations" and occupation code 43-6011 "Executive Secretaries and Executive Administrative Assistants." To calculate the hourly wage rates for every year of the analysis PHMSA took into consideration an estimated 1.18 percent annual growth rate in median real wages. [114] After inflating the average hourly wage of $38.17 by 1.18 percent, we calculated an average hourly wage of $38.62 in 2014. PHMSA then inflated this wage by 60 percent to account for fringe benefits and overhead of $23.17 per hour, for a total weighted hourly wage of $61.80 in 2014. Following the same series of calculations (and holding the fringe benefit constant at $23.17), the total weighted hourly wage in 2015, the first year of the analysis, was estimated at $62.25. The resulting average hourly wage rate calculated for the subsequent years of the analysis (years 2-20) is $67.21.

PHMSA developed costs analogously to how they were estimated during the HM-232E rulemaking.

The final rule's routing section requires rail carriers to use the data to analyze the safety and security risks for the transportation route(s) used to transport HHFTs on an annual basis. Rail carriers also must analyze this data to establish the primary HHFT routes, analyze its rail network, consider 27 risk factors, and reassess these risks and routing decisions annually. We assumed that the initial incorporation of HHFTs into route analysis would be more resource intensive than assessments in later years. This assumption was based on the belief that limited changes in rail networks make the task of assessing alternative routes and safety risks easier in later years than in the initial year.

Annual Data Collection by Line Segment

As previously noted, the final rule requires a rail carrier transporting HHFTs to use the data it compiles to annually analyze the safety and security risks for the transportation route(s) used to by these trains. In performing this analysis the rail carrier must consult with state, local, and

[113] Available online at http://www.bls.gov/oes/current/oessrci.htm

[114] Based on real wage growth forecasts from the Congressional Budget Office, DOT's guidance estimates that there will be an expected 1.18 percent annual growth rate in median real wages over the next 30 years (2013-2043). The wage rate in 2014 is calculated as follows: $\$38.17 * 1.0118 + \$38.17 * 1.0118 * 0.6 = \$61.80$.

tribal officials, as appropriate, regarding security risks to high-consequence targets, countermeasures already in place, and the community emergency response capability along, or in proximity to, the route(s) utilized.

Hazmat shipment data is readily available to large railroads. Because small railroads do not frequently carry the hazardous materials addressed in this final rule, they may know exactly what commodities they carry and when. Small railroads that carry hazmat less frequently may not have electronic data and may have to physically search their records for this information. Both large and small railroads are assumed to require 40 hours to collect the data with which they analyze routes. This data would consist of collecting waybill data on the commodities covered by the requirement, examining origins and destinations for these shipments, identifying the routes over which these commodities travel, and identifying viable alternative routes. In addition, information on the safety characteristics of current routes and alternatives would have to be collected. This data includes population densities, derailment rates, track class, etc. These costs reoccur annually. The table below presents the estimated costs for this task for Year 1. [115]

Table R2: Annual Data Collection by Rail Group

Annual Data Collection by Rail Group

Railroad size	Number of Railroads in Class Affected	Max. No. of Hours	Hourly Labor Rate	Max. No. of Hours x Hourly Labor Rate
Class I	0	0	$0.00	$0
Class II	10	40	$62.25	$24,901
Class III	160	40	$62.25	$398,422
			Total:	$423,323

Primary Safety and Security Route Analyses: Year 1

The primary route analyses conducted in year 1 will cost more than the analyses done in subsequent years. The cost estimates presented here may overestimate costs for this requirement because, as mentioned above, much of the analytical work has already been done to comply with previous routing requirements.

An important determinate of costs is the number of routes that must be analyzed. An example of a route is a major corridor. In general, large railroads carry hazmat farther distances than small railroads. Therefore, the large railroads are estimated to have more routes per carrier than the small railroads. It is also anticipated that large railroads will have more complex route analyses to perform. In this analysis, PHMSA assumed that the small railroads, due to their limited size, would typically have no less than one and no more than two primary routes to analyze.

[115] From 2016 to 2034, the total cost of annual data collection is equal to $8,683,304.

Therefore, for 160 small railroads, there is a maximum of 320 primary routes to be analyzed. Because the distance covered by the small railroads' routes is likely contained within a limited geographic region, the hours estimated for analyses are fewer than those estimated for the larger railroads.

The number of routes and hours were used to estimate this cost element to ensure that full costs for developing route analyses and choosing alternative routes is captured. PHMSA assumed in its analysis that the railroads will consider each major corridor as a single route to minimize the number of routes analyzed. The rule does not mandate how the railroads identify each route, but it is reasonable to assume that railroads will use economic best practices. The initial analysis and route selection must include a comprehensive review of a carrier's entire system and include mitigation measures that the carrier intends to implement to increase the safety and security of the route(s).

Class II railroads are more likely to have several primary routes; Class III railroads operate over less track mileage. The Class II railroads analyze all alternate routes to determine, given the operation knowledge of the carrier, the route of a particular shipment on a particular day. Class II railroads are estimated to have a maximum of 50 routes combined. Class III railroads are estimated to have a maximum of 320 routes. These numbers are high and are not intended to suggest that this number of major corridors exist. The numbers are representative of all possible routes for the commodities included in this final rule. These numbers represent existing track infrastructure and are overstated to account for further unexpected route changes and potential acquisitions that may or may not occur.

Class II railroads are estimated to require 80 hours per route to conduct the initial analysis of primary routes. A Class III railroad is estimated to require 40 hours per route. PHMSA calculated total costs for analyzing routes for each class of railroad by multiplying the number of routes by the number of hours required to analyze a route and the calculated labor rate. These costs are presented in the table below.

Table R3: Year 1 Costs of Safety and Security Route Analyses

Primary Route Analysis by Rail Group – Year 1

Railroad Size	Number of Railroads in Class Affected	Number of Routes	Number of Hours per Route	Labor Rate	Number of Routes * Hours * hourly labor rate
Class I	0	0	0	$0.00	$0
Class II	10	50	80	$62.25	$249,014
Class III	160	320	40	$62.25	$796,843
				Total:	$1,045,857

Annual Primary Safety and Security Route Analyses: Years 2-20

After the first year's route analyses are completed, PHMSA expected that analyses performed on the same routes in subsequent years would take less time. We anticipated that the majority of the routes analyzed in year 1 would continue to be used in future years. Therefore, these routes

would require only a review to ensure there have been no changes or planned mitigation measures that would affect the analyses in the future years. It was also assumed that there would be few changes in the high-consequence facilities located along or in proximity to these routes. It was further assumed that the railroads would experience some change in commodity flow that will affect their primary routes each year. However, a learning curve is anticipated. For these reasons, the primary route analyses would be conducted annually, but each subsequent year would take less time.

Rail companies would analyze the same number of routes in later years as described above in the initial year analysis section. PHMSA estimated that a Class II railroad would require 16 hours per route to update route analyses on an annual basis. PHMSA estimated that a Class III railroad would require eight hours per route. The cost estimates for subsequent year analyses are calculated in the same manner as the initial year. The cost estimates for this task are presented in the table below.

Table R4: Years 2-20 Costs of Safety and Security Route Analyses
Route Analysis by Rail Group

Railroad Size	Number of Railroads in Class Affected	Number of Routes	Number of Hours per Route	Number of Routes x Hours x Hourly Labor Rate
Class I	0	0	0	$0
Class II	10	50	16	$1,021,565
Class III	160	320	8	$3,269,009
			Total:	$4,290,574

Alternate Route Economic, Safety, and Security Analyses: Year 1

As previously noted, the final rule requires a rail carrier operating HHFTs to use the data it compiles to annually analyze the safety and security risks for all practicable alternative routes which the carrier is authorized to use. When determining practicable alternative routes, the rail carrier would consider the use of interchange agreements with other rail carriers. We expect that rail carriers would also consider the potential economic effects of using the alternative route, including, but not limited to, the economics of the commodity, route, and customer relationship. The rail carrier would also consider any remediation measures it intends to implement on a route. Using this process, the carrier would be required, at least annually to compare the safety and security risks on the primary and alternative routes and select the practicable route posing the least risk to safety and security.

When selecting a primary route for the transport of hazmat, rail carriers normally analyze all routes they consider commercially and economically practicable. As stated previously, large rail carriers are more likely to have alternate routes than smaller rail carriers, which operate over fewer tracks. The larger rail carriers analyze all practicable alternate routes to determine, given the operational knowledge of the rail carrier, the route of a particular shipment on a particular day. The average number of practicable alternate routes analyzed by Class II railroads is four per railroad. Larger rail carriers, Class I and Class II, carry hazardous materials farther distances than smaller, Class III railroads. A practicable alternate route may not be available in many

instances to a Class III railroad. This analysis conservatively assumes that half of the Class III railroads have practicable alternate routes resulting in 80 routes to analyze.

Class II railroads are estimated to require 120 hours to analyze each alternate route in the initial year for incorporation of HHFTs into routing plans. A Class III railroad is estimated to require 40 hours per alternate route. PHMSA calculated total costs for analyzing routes for each class of railroad by multiplying the number of routes by the number of hours required to analyze a route and the calculated labor rate. These figures are presented in the table below.

Table R5: Alternate Route Analyses by Rail Group– Year 1

Railroad Size	Number of Railroads in Class Affected	Number of Routes	Number of Hours per Route	Labor Rate	Number of Routes * Hours * Hourly Labor Rate
Class I	0	0	0	$0.00	$0
Class II	10	40	120	$62.25	$298,816
Class III	160	80	40	$62.25	$199,211
				Total:	$498,027

Alternate Route Economic, Safety, and Security Analyses: Years 2-20

Subsequent alternative route analysis would include:

- A comprehensive, system-wide review of all operational changes;
- Infrastructure modifications;
- Traffic adjustments;
- Changes in the nature of high-consequence targets located along, or in proximity to, the routes; and
- Any other changes affecting the safety or security of the movements of HHFTs that were implemented during the calendar year, as well as mitigation measures the carrier intends to implement.

Performing the alternate route analyses in years 2 through 20 is assumed to require 10 percent of the time the first year's route analyses required. This is based on estimates of limited changes in commodity flow or shipment volume and other changes that would affect practicable alternative routes to the primary route. The previously analyzed alternate routes will require some review to ensure there have been no changes that would affect the analyses in the future years; however, a learning curve is anticipated. These costs are presented in the table below.

Table R6: Alternate Route Analyses by Rail Group – Years 2-20

Railroad Size	Number of Railroads in Class Affected	Number of Routes	Number of Hours per Route	Number of Routes * Hours * Hourly Labor Rate
Class I	0	0	0	$0
Class II	10	40	12	$612,939
Class III	160	80	4	$408,626
			Total:	$1,021,565

Routing Requirements Total Cost

The table below presents total estimated costs for this final rule over 20 years. These costs reflect the resources required to collect data, analyze current shipping routes for HHFTs, and identify alternative routes, where feasible, that lower the overall risk of transporting this hazardous material. The annual costs for this requirement are shown in Table R7 and the annual cost of this requirement by railroad class is shown in Table R8. The total cost over 20 years will be $12,084,292 at 3 percent discount rate and $8,846,214 at 7 percent discount rate.

Table R7: Annual Costs of Routing
Costs of Regulation by Year

Year	Costs
1	$1,967,207
2	$687,351
3	$692,465
4	$697,639
5	$702,874
6	$708,171
7	$713,530
8	$718,953
9	$724,439
10	$729,991
11	$735,607
12	$741,291
13	$747,041
14	$752,859
15	$758,745
16	$764,702
17	$770,728
18	$776,826
19	$782,995
20	$789,237
Total:	$15,962,650
Present Value at 3% Discount Rate:	$12,084,292
Present Value at 7% Discount Rate:	$8,846,214

Table R8: Annual Cost of Routing Regulation by Railroad Class

Year	Class II	Class III
1	$572,731	$1,394,476
2	$105,360	$581,991

Table R8: Annual Cost of Routing Regulation by Railroad Class		
3	$106,144	$586,321
4	$106,937	$590,702
5	$107,740	$595,134
6	$108,552	$599,619
7	$109,373	$604,157
8	$110,204	$608,748
9	$111,045	$613,394
10	$111,896	$618,094
11	$112,757	$622,850
12	$113,629	$627,662
13	$114,510	$632,531
14	$115,402	$637,457
15	$116,304	$642,441
16	$117,217	$647,485
17	$118,141	$652,587
18	$119,075	$657,750
19	$120,021	$662,974
20	$120,978	$668,259
Total	$2,718,018	$13,244,632
3% Discount Rate	$2,115,627	$9,968,666
7% Discount Rate	$1,609,436	$7,236,778

Routing Requirement Benefits

As noted above, Glickman et al analyzed the risk reduction benefits that might be achieved by rerouting hazardous material rail shipments to lower risk routes using a rail simulation model.[116] The authors found that substantial risk reductions could be obtained for modest or no increase in shipment mileage. In some cases, their modeling identified lower-risk routes that actually decreased mileage. Obtainable risk reductions vary depending on the shipment's origin and destination, but the aggregate conclusion for all routes analyzed was that a 22 percent risk reduction could be obtained with an increase of roughly 5 percent in total shipment mileage.

It is important to note that risk can be minimized practically in two ways: one is to run shipments over the highest-quality track, i.e. track that poses the lowest risk for derailment, collision, or other train accident. The other way risk can be reduced is to reduce exposure to train accidents.

[116] Glickman, Theodore S. Erkut, Efhan, and Zschocke, Mark S. 2007. The cost and risk impacts of rerouting railroad shipments of hazardous materials. Accident Analysis and Prevention. 39. 1015-1025.

Rerouting can address either or both of these risk factors, but in some cases, one factor must be traded off against another.

For instance, rail track may be better maintained in areas of high population density; therefore, accidents may be more likely in a rural area. However, should a hazardous material train accident occur in a high population area, the consequences might be much more severe consequences than in a less populous area because more people are at risk of exposure, injury, or death. In addition property value loss and the amount of infrastructure that may be destroyed is much higher in urban, high population areas.

This final rule requires railroads to balance these factors to identify the route that poses the lower risk. In some cases, rail carriers might choose a route that eliminates exposure in areas with high population densities but poses a risk for more frequent events in areas with low population densities. In other cases, the risk of derailment may be so low along a section of track that, even though it runs through a densely populated area, it poses the lowest total risk when severity and likelihood are considered. Glickman's estimate of safety improvements achievable by routing changes is based on an examination of how routing might vary as a rail carrier applies progressively heavier weights on various safety factors. In practice, it is impossible to know how much weight rail carriers will give to safety when making routing decisions. As noted above, based on past routing plans submitted by rail carriers to FRA for approval, application of the routing requirements resulted in modest changes to company routing decisions. It is therefore unclear to what extent these requirements would improve safety. However, even if very small, reductions in the risk of an adverse event due to the improved routing of HHFTs could produce benefits that outweigh the costs. For example, our current estimate of the total undiscounted lower-consequence damages of crude and ethanol derailments over the coming 20 years is expected to be approximately $4.1 billion.

PHMSA conducted a break-even analysis in Table R9 based on the estimated damages from lower-consequence events. Table R10 shows the prevented damages at the break-even point over the 20 years.

Table R9: Break-even Analysis

	Estimated Damages (in millions)	**Costs of Regulation (in millions)**	**Break-even Effectiveness Rate**
Undiscounted	$4.093	$16	0.39%
PV 3%	$3,037	$12	0.40%
PV 7%	$2,152	$9	0.41%

Table R10: Prevented Damages at the Break-even Point		
Year	**Total Lower-consequence Benefits – Routing - 3% discounted**	**Total Lower-consequence Benefits – Routing - 7% discounted**
2015	$694,855	$691,326
2016	$661,538	$633,573
2017	$665,388	$613,438
2018	$693,923	$615,829
2019	$715,359	$611,120
2020	$737,959	$606,859
2021	$720,313	$570,204
2022	$700,478	$533,774
2023	$636,217	$466,682
2024	$662,372	$467,704
2025	$641,565	$436,077
2026	$611,263	$399,949
2027	$545,047	$343,292
2028	$557,807	$338,195
2029	$531,933	$310,451
2030	$506,434	$284,520
2031	$483,002	$261,212
2032	$460,143	$239,546
2033	$439,214	$220,103
2034	$419,483	$202,357
Total	$12,084,292	$8,846,214

To break even, the routing requirement must achieve an effectiveness rate of 0.40% and 0.41% to be beneficial (the benefits would outweigh estimated costs, excluding the costs of added shipping miles) at three percent respectively seven percent discount rates. PHMSA believes this requirement would achieve at least that level of effectiveness.

Route planning and route selection provisions currently required for explosive, PIH, or radioactive materials are not required on HHFTs. Although crude oil carriers took voluntary actions, codifying the Secretary's Call-to-Action is necessary. Codification is also a check on higher-risk routes or companies. There is nothing in place/no incentive to require continued compliance with voluntary actions.

If the final rule is not adopted, railroads would not be required to conduct route risk analysis nor would they be required to reroute shipments over lower-risk routes. Specific identified criteria for the route and alternate route analyses may not be uniformly considered by all railroads, and written analyses of primary and alternate routes including safety and security risks would not be

required. The costs to society, the government, and the rail industry of an accident involving a HHFT are high. If no action to better evaluate routing decisions, the threat of catastrophic accidents in large populated areas or other sensitive environments will continue.

B. Requirement Area 2 – Tank Car

Final Action: PHMSA is requiring Option 2 car required for new construction, Option 3 car for retrofits

PHMSA is requiring new tank cars constructed after October 1, 2015 used to transport Class 3 flammable liquids in an HHFT to meet either:

1) The prescriptive standards for the DOT-117 tank car, which is consistent with Option 2 of the NPRM except for the braking component;

or

2) The performance standards for the DOT-117P tank car.

In this final rule, we are also adopting retrofit requirements for existing tank cars in accordance with proposed Option 3 from the NPRM (excluding top fittings protection and steel grade). If existing cars do not meet the retrofit standard, they will not be authorized for use in HHFT service after the deadlines specified within the adopted risk-based implementation timeline. This in effect adopts different constructions standards for new and retrofitted cars used in an HHFT.

1. Determination of Need

DOT conducted research on long-standing safety concerns regarding the survivability of the DOT-111 tank cars designed to the current HMR and used for the transportation of crude oil and ethanol. The research found that special consideration is necessary for the transportation of crude oil and ethanol in DOT-111 tank cars, especially when a train is configured as a HHFT. It is not possible to eliminate the probability that an accident involving multiple tank cars will occur. However, the increased number of trains consisting of a large number of tank cars carrying flammable liquid poses an emergent safety risk, as described above.

We estimate that there are approximately 335,000 tank cars (pressure and non-pressure) in today's fleet, of which 272,000 are DOT-111 tank cars. Of those 272,000, approximately 86,000 tank cars are used to transport ethanol or crude oil. Major derailments often result in the release of hazardous materials, the severity of these accidents depends on the weight of a tank car, train speed, and the volume of hazardous materials transported. In published findings from the June 19, 2009, train accident in Cherry Valley, Illinois, the NTSB indicated that the DOT-111 tank car

can usually be expected to breach in the event of a derailment resulting in car-to-car impacts or pileups.

Modeling and simulation of the puncture of DOT-111 tank cars currently used to transport ethanol or crude oil indicate that when struck at a velocity of approximately 7.4 mph at the longitudinal center of the tank shell with a rigid 12" x 12" indenter with a weight of 297,000 pounds, DOT-111s will result in a puncture.[117] Validation of this model has been accomplished using the results of puncture tests performed at the Transportation Technology Center in Pueblo, CO. Further, based on modeling and simulation, the head of an unjacketed DOT-111 tank car will puncture at 7.6 mph when struck with a 12" x 12" indenter weighing 286,000 pounds. Table TC2 provides the tank car shell and head puncture velocities of the DOT-117 tank car Options proposed. Similar to the methodology for estimating the effectiveness of new cars, PHMSA used the calculated puncture velocities to arrive at risk reduction estimates for retrofits. As discussed below and in the NPRM, these data show that the DOT-111 is significantly more likely to puncture than the proposed alternatives.

All of the tank car options were designed to address the survivability of the tank car and would mitigate the damages of rail accidents better than the current DOT-111. Specifically, the tank car options incorporate several enhancements in order to increase puncture resistance; provide thermal protection to survive a 100-minute pool fire; and protect bottom outlets during a derailment. Under all options, the system of design enhancements would reduce the consequences of a derailment of tank cars carrying flammable liquids. There would be fewer car punctures, fewer releases from the service equipment (top and bottom fittings), and delayed and reduced volumes of flammable liquid releases through the pressure relief devices.

2. Proposed Tank Car Specification Requirements

PHMSA proposed three options for newly manufactured DOT-111 tank cars to address the risks associated with HHFTs. In addition, we proposed to allow for tank cars to meet a performance standard equivalent to the selected prescribed tank car standard, which could be accomplished by designing a new car or retrofitting existing DOT-111 tank cars. The changes stipulate a new tank car prescribed and performance tank car—the DOT-117 tank car—that will be phased in over time depending on the Packing Group of the flammable liquid. The provisions allow for tank cars to meet a performance standard equivalent to the DOT-117, which could be accomplished by retrofitting existing DOT-111/CPC-1232 tank cars. Cars that meet the DOT-117 performance standard would be designated DOT-117P.

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[117] "Detailed Puncture Analyses Tank Cars: Analysis of Different Impactor Threats and Impact Conditions" can be found at: http://www.fra.dot.gov/eLib/details/L04420

The following shorthand is used to denote the various car configurations being discussed throughout this document:

1) Non-Jacketed DOT-111 cars: DOT-111NJ
2) Jacketed DOT-111 cars: DOT-111J
3) Non-Jacketed CPC-1232 cars: CPC-1232NJ
4) Jacketed CPC-1232 Cars: CPC-1232J
5) Jacketed CPC-1232 car with an enhanced bottom outlet valve handle and higher-capacity pressure relief valve (enhanced CPC-1232 J or Option 3 tank car)
6) Tank car with 9/16^{ths} inch shell thickness, jacket, full height head shields, thermal protection, enhanced bottom outlet valve handle and high capacity pressure relief valve: AAR 2014 tank car or Option 2 tank car
7) Tank car with all of the above, rollover protection, and ECP brakes (PHMSA FRA tank car or Option 1 tank car)

Three options were considered at the NPRM stage: 1) Universal retrofitting to the Option 1 tank car standard, 2) universal retrofitting of the fleet to the Option 2 standard, and 3) universal retrofitting of the fleet to the Option 3 standard. The final rule that this document accompanies establishes a hybrid approach with one standard for retrofit cars and another for cars that are newly constructed after the date established by the final rule. The retrofit standard requires that cars must perform at a level equivalent to a 7/16ths-inch CPC-1232 car with a jacket, thermal protection, and full height head shields – the Option 3 car. New cars would be built to the AAR standard – the Option 2 car or the performance equivalent of this car. This hybrid approach was supported for by the industry commenters. It ensures that the retrofit standard is technically feasible, and establishes a safer tank car standard for new builds. The estimated costs in this chapter have been adjusted to reflect this change.

Under the HMR, the offeror must select a packaging that is suitable for the properties of the material. The DOT-111 tank car is one of several cars authorized by the HMR for the rail transportation of hazardous materials. The DOT-111 tank car, which can be jacketed or non-jacketed, is the tank car most often used for almost all crude oil and ethanol shipments by rail.

Table TC1: Current Authorized Tank Cars[118]		
Flammable Liquid, PG I	**Flammable Liquid, PG II and III**	**Combustible Liquid**
DOT 103	DOT 103	DOT 103
DOT 104	DOT 104	DOT 104
DOT 105	DOT 105	DOT 105
DOT 109	DOT 109	DOT 109
DOT-111	DOT-111	DOT-111
DOT 112	DOT 112	DOT 112
DOT 114	DOT 114	DOT 114
DOT 115	DOT 115	DOT 115
DOT 120	DOT 120	DOT 120
	AAR 206W	AAR 206W
		AAR 203W
		AAR 211W

In 2011, AAR issued Casualty Prevention Circular (CPC) 1232, which outlines industry requirements for DOT-111 tanks ordered after October 1, 2011, intended for use in ethanol and crude oil service. This construction was approved by FRA on January 25, 2011 – see the Background below for a detailed description of the PHMSA and FRA actions allowing construction under CPC-1232). The key tank-car requirements contained in CPC-1232 include the following:

1) PG I and II material tank cars to be constructed to AAR Standard 286; AAR Manual of Standards and Recommended Practices, Section C, Car Construction Fundamentals and Details, Standard S-286, Free/Unrestricted Interchange for 286,000 lb. Gross Rail Load (GRL) Cars (AAR Standard 286);
2) Head and shell thickness must be 1/2 inch for TC-128B non-jacketed cars and 7/16 inch for jacketed cars;
3) Shells of non-jacketed tank cars constructed of A5l6-70 must be 9/16 inch thick;
4) Shells of jacketed tank cars constructed of A5l6-70 must be 1/2 inch thick;
5) New cars must be equipped with at least 1/2 inch, half-height head shields;
6) Heads and shells must be constructed of normalized steel;
7) Top fittings must be protected by a protective structure as tall as the tallest fitting; and
8) A reclosing pressure relief valve must be installed.

[118] Additional information on tank car specifications is available at the following URL: http://www.bnsfhazmat.com/refdocs/1326686674.pdf

The CPC-1232 is a voluntary industry improvement on the DOT-111. The technical background for its safety features, as well as the proposed safety features in the three tank car options, are described more fully in the preamble to the final rule.

PHMSA is requiring new tank cars constructed after October 1, 2015 to meet the new design or performance standard, if those tank cars are used as part of an HHFT. The retrofit schedule for existing tank cars to an enhanced CPC-1232 standard (Option 3 tank car) when used as part of an HHFT is presented in the following table:

Table TC2: Final Rulemaking: Implementation Timeline based on Recommendations from Public Comments

Tank Car Type / Service	Retrofit Deadline	Estimate of Tank Cars Retrofitted
Non-Jacketed DOT-111 tank cars in PG I service	December 2017 (33 months)	11,637
Non-Jacketed DOT-111 tank cars in PG II service	April 2020 (61 months)	18,493
Jacketed DOT-111 tank cars in PG I and PG II service	November 2020 (68 months)	2,356
Non-Jacketed CPC-1232 tank cars in PG I and PG II service	June 2023 (99 months)	15,895
Jacketed CPC-1232 tank cars in PG I, PG II service, and all remaining tank cars carrying PG III materials in an HHFT (pressure relief valve and valve handles).	April 2025 (121 months)	24,933
Assumes an April 1, 2015 publication date and the retrofit deadline is last day of month indicated. Actual dates will vary depending on publication date.		

The retrofit schedule has been lengthened significantly in response to industry comments regarding the feasibility of completing retrofits under the timelines proposed at the NPRM stage.

The final schedule for when retrofits have to be completed is presented in the table below. Based on comments, we assume that the industry would need a 6 month ramp-up in order to prepare to begin retrofitting cars, and after that, they would retrofit legacy DOT-111s to capacity until work is complete.

Retrofit Schedule		
Tank Car Type / Service	**Fleet Size**	**DOT Revised Schedule**
Non Jacketed DOT-111 tank cars in PG I service	11,637	**(January 1, 2017)**[119] **January 1, 2018**
Jacketed DOT-111 tank cars in PG I	2,268	**March 1, 2018**
Non Jacketed CPC-1232 tank cars in PG I service	15,144	**April 1, 2020**
Non Jacketed DOT-111 tank cars in PG II service	18,493	**May 1, 2023**
Jacketed DOT-111 tank cars in PG II service	88	**May 1, 2023**
Non Jacketed CPC-1232 tank cars in PG II service	751	**July 1, 2023**
Jacketed CPC-1232 tank cars in PG I and PG II service* and all remaining tank cars carrying PG III materials in an HHFT (pressure relief valve and valve handles).	24,993	**May 1, 2025**

3. Tank Car Alternatives

PHMSA considered the status quo and three tank car options at the NPRM stage. In this final rule, PHMSA adopted a hybrid that sets the retrofit standard at the Option 3 standard and the new car standard at the Option 2 standard. In addition, as explained in the braking section of this analysis, some cars in crude oil and ethanol service are required to be equipped with ECP brakes.

No-Action Alternative

This alternative would continue to authorize the use of the non-jacketed and jacketed DOT-111 tank cars, including non-jacketed and jacketed CPC-1232 tank cars, for the transportation of crude oil and ethanol. This alternative would impose no benefits or costs, because it would require no change in flammable liquid packaging.

[119] The January 1, 2017 date would trigger a retrofit reporting requirement, and tank car owners of affected cars would have to report to DOT the number of tank cars that they own that have been retrofitted, and the number that have not yet been retrofitted.

Final Rule Option: Option 2 car required for new construction, Option 3 car for retrofits

The final rule option is the tank car design option enacted into regulation by the final rule document that the final RIA accompanies. As discussed above, this option requires existing cars to be retrofit to an enhanced CPC-1232J, or Option 3 standard and newly constructed cars to be built to the Option 2, or AAR 2014, tank car standard. The features of the Option 2 standard are identical to those on the CPC-1232J except that the Option 2 car has a 9/16ths inch thick shell, whereas the CPC-1232J has a 7/16ths inch shell. This makes the Option 2 car less likely than the Option 3 car to release its contents in the event of an incident such as a derailment or collision. Table TC2 presents the safety features of all cars considered in this document. We considered the costs and benefits of all Options proposed at the NPRM stage as well as the final rule option. Key features of the Option 2 car include the following:

- 286,000 lb. GRL tank car that is designed and constructed in accordance with AAR Standard S-286;
- Wall thickness after the forming of the tank shell and heads must be a minimum of 9/16 inch, constructed from TC-128 Grade B, normalized steel;
- Thermal protection system in accordance with § 179.18, including a reclosing pressure relief device;
- Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight as required in § 179.200-4;
- Full-height, 1/2 inch thick head shield meeting the requirements of § 179.16(c)(1);
- Bottom outlet handle removed or designed to prevent unintended actuation during a train accident; and
- Top fittings protection meeting the requirements of § 179.102-3 (not applicable to existing tank cars).

Option 1: PHMSA FRA Tank Car

This tank car has the safety features listed above plus:

- ECP brakes; and
- Rollover protection for new construction, but not for retrofits. Retrofitting rollover protection on thinner shelled cars was deemed impossible and hence was not required at the NPRM stage.

Option 3: Enhanced Jacketed CPC-1232 Tank Car

This tank car standard is also presented in detail in the initial RIA. For the details on this option's requirements, the Agency refers the reader to that document. This car has identical safety features to the Option 2 car with the exception of shell thickness, which is 7/16ths inch, an eighth of an inch thinner than the Option 2 car. As previously noted, the final rule establishes this tank car as the standard to which all currently existing cars must be retrofit to.

Table TC3, below, compares the safety features associated with the three tank car options proposed in the NPRM. Since the final rule adopts a hybrid of Options 1 through three, the features of this option are also presented below.

Table TC3: Safety Features by Tank Car Option

Tank Car	Bottom Outlet Handle	GRL (lbs.)	Head Shield Type	Pressure Relief Valve	Shell Thickness	Jacket	Tank Material*	Top Fittings Protection **	Thermal Protection System	Braking
Option 1: PHMSA and FRA Designed Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full-height, 1/2 inch thick head shield	Reclosing pressure relief device	9/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	TIH Top fittings protection system and nozzle capable of sustaining, without failure, a rollover accident at a speed of 9 mph	Thermal protection system in accordance with § 179.18	ECP brakes
Option 2: AAR 2014 Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full-height, 1/2 inch thick head shield	Reclosing pressure relief device	9/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	Equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Thermal protection system in accordance with § 179.18	DP or Two-way EOT devices
Option 3: Enhanced CPC-1232 Tank Car	Bottom outlet handle removed or designed to prevent unintended actuation during a train accident	286k	Full height 1/2 inch thick head shield	Reclosing pressure relief device	7/16-inch minimum	Minimum 11-gauge jacket constructed from A1011 steel or equivalent. The jacket must be weather-tight	TC-128 Grade B, normalized steel	Equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Thermal protection system in accordance with § 179.18	DP or Two-way EOT devices
DOT-111A100W1 Specification (Currently Authorized)	Bottom outlets are optional	263K	Optional; bare tanks half height; jacket tanks full height	Reclosing pressure relief valve	7/16-inch-minimum	Jackets are optional	TC-128 Grade B, normalized steel*	Not required, but when equipped per AAR Specifications for Tank Cars, Appendix E paragraph 10.2.1	Optional	EOT device (See 49 CFR part 232)

* For the purposes of this figure, TC-128 Grade B normalized steel is used to provide a consistent comparison to the proposed options. Section 179.200-7 provides alternative materials, which are authorized for the DOT Specification 111.

** Please note PHMSA has not required additional top fittings protection for retrofits. While PHMSA expects additional top fittings protection would provide enhanced safety protection, the costs of retrofitting existing cars exceed the safety benefits by $500 million to $1 billion. Newly constructed cars, however, are required to have top fittings protection.

Baseline

The baseline for this assessment is the current HMR, with some modifications to account for other regulatory initiatives that will reduce the risk of a catastrophic event. Later in this section, we use the lower consequence event damages presented as a pool from which to draw benefits. At present, we consider the cost of each proposed tank car standard.

For purposes of analyzing the tank car options, the baseline consists of a forecast of the size of the tank car fleet size, and its characteristics, in absence of the proposed tank car standard. The fleet is expected to evolve the same way for all the Options analyzed here. Regarding the tank car fleet, PHMSA assumed that all newly constructed tank cars for flammable liquid service in HHFTs would adhere to the enhanced CPC-1232 standard (Option 3 tank car) in the absence of a revised standard in the HMR. The CPC-1232 has been the industry standard for orders placed after October 2011, and PHMSA assumed that 100 percent of the newly constructed tank cars will be CPC-1232 jacketed tank car plus improvements to pressure relief devices and bottom outlet valves (i.e., the "enhanced jacketed CPC-1232"). This an assumption based on a commitment made by rail car manufacturers. It is also assumed that the DOT-111 and the CPC-1232 cars have life spans of 40 years and 50 years, respectively.

The fleet figures are based on comments to the NPRM by RSI, with some modifications. The RSI comments project fleet growth to 2025 along with a forecast of the number of carloads shipped by rail. The figures presented by RSI appear to be for the entire North American fleet. The first adjustment PHMSA and FRA made to these figures is to remove the 25.7 percent of cars estimated to be owned and leased by Canadian companies. PHMSA assumed these cars would be built to and governed by standards established by Canadian Transport Dangerous Goods regulations rather than the U.S. HMR. Secondly, it appears that the RSI figures may result in the overbuilding of tank cars for HHFT service. Using their figures results in a declining number of trips the average car makes per year. This was calculated by dividing RSI's estimate of the number projected carloads into RSI's estimate of the number of cars. In 2013 the AAR reported that there were 483,701 crude oil tank cars originating in North America, with 401,813 originating in the US and 81,888 in Canada. This gives us average shipments per car of 11.2[120] per year for crude oil. In 2013, the AAR reported that there were 290,710 alcohols (not otherwise specified) n.o.s. (ethanol) tank cars originating in North America, with 290,709 originating in the US and one in Canada. This gives us average shipments per car of 10.8[121] per year for ethanol.

[120] 483,701 (Carloads of Crude oil) / 43,288 (number of cars used in 2013) = 11.174

[121] 290,710 (Carloads of Ethanol) / 27,024 (number of cars used in 2013) = 10.757

Based on the 2013 AAR report on car utilization, it appears that the average crude oil car made approximately 11.2 trips. Using RSI's projection, peak carloads for crude oil service results in 1,004,852 carloads transported by roughly 96,590 tank cars. This translates to 10.4[122] shipments per car in the peak year. This shows a 7.1 percent decrease in utilization rate (efficiency) from 2013. Various sources indicate that cycle times have improved over the past year or so – as a result, it seems unlikely that as many cars would be needed as RSI projects. In this analysis, PHMSA estimated a utilization rate of 16.0 (or number of completed round trips annually), or 22.8 days in a cycle time for HHFTs.

Finally, as described in the ECP Braking section, we expect deployment of ECP braking on a portion of tank cars to increase the efficiency of these trains, resulting in fewer cars needed to move the same amount of product. We do not count a reduction in cars as a benefit here. Fewer cars do mean lower new construction costs, but the only benefits claimed in this section are tank car safety benefits. PHMSA assumed that anything scheduled to be delivered in 2015 will be delivered as ordered and retrofit later. Table TC4 shows the current fleet composition:

Table TC4: Estimates for current fleet of rail tank cars[123]

Tank Car Category	Population
Total No. of Tank Cars Hauling Crude Oil	59,401
Total No. of Tank Cars Hauling Ethanol	26,546
CPC-1232 (Jacketed) in Crude Oil Service	24,910
CPC-1232 (Jacketed) in Ethanol Service	23
CPC-1232 (Non-Jacketed) in Crude Oil Service	15,144
CPC-1232 (Non-Jacketed) in Ethanol Service	751
DOT-111 (Jacketed) in Crude Oil Service	3,185
DOT-111 (Jacketed) in Ethanol Service	88
DOT-111 (Non-Jacketed) in Crude Oil Service	16,163
DOT-111 (Non-Jacketed) in Ethanol Service	25,685

[122] 1,004,852 (RSI Forecast of carloads of Crude in 2021) / 965,90 (RSI estimate of number of cars used) = 10.403

[123] Source: RSI presentation at the NTSB rail safety forum April 22, 2014, update provided on June 18, 2014.

The crude and ethanol fleet is relatively new. Consultation with FRA industry experts, industry trade magazines, and crude and ethanol shippers indicates that most of the crude and ethanol fleet has been built since 2000.[124] At the NPRM stage, PHMSA and FRA assumed that virtually the entire fleet would be retrofit. In response to comments, however, we have revised this assumption. Based on comments from several industry groups, we predict that approximately 28 percent of legacy cars (i.e., tank cars that predate the CPC-1232 standard) would be retired rather than retrofit. A review of the distribution of DOT-111 tank car ages corroborates this figure, and PHMSA and FRA therefore believe it to be accurate. This percentage appears to correspond to the percentage of cars that were built prior to approximately the year 2000. Thus, any car older than 15 years of age is likely to be retired rather than retrofit.

As noted above, PHMSA based its fleet projection for the final rule primarily on comments submitted by RSI with adjustments to remove intra-Canadian movements, a reduction to reflect PHMSA's estimated utilization rates, and some adjustment to reflect greater efficiencies that will be gained by adoption of ECP brakes. As can be seen in the table below, the new forecast estimates are lower figures than those used at the NPRM stage. Primarily, this is a function of removing shipments/cars originating and ending in Canada from the fleet. It has become clear that the Agency's NPRM estimates included intra-Canada cars resulting in an overestimation of the U.S. fleet by approximately 25.7 percent.

The table below presents tank car fleet size forecasts for crude oil and ethanol. Although ethanol shipments are forecast to grow moderately for the coming several years, consultation with the industry indicates that the ethanol fleet is large enough at present to accommodate the increase in volume. Since there is no demand or need for more ethanol cars going forward, PHMSA assumed no growth in the manufacture of ethanol cars. We estimate the current ethanol fleet at 30,000 cars. As such, all fleet growth is attributable to the crude oil fleet.

Table TC4: Fleet Forecast DOT-111 and CPC-1232 from 2014-2034

	DOT-111 Unjacketed		DOT-111 Jacketed		CPC 1232 Unjacketed		CPC-1232 Jacketed		Planned New Construction
Base Year Fleet	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953
Year	Retro fits*	Retire ments	Retro fits	Retire ments	Retro fits*	Retire ments	Retro fits	Retire ments	New
2015	0	0	0	0	0	0	651	0	0
2016	4,413	0	0	0	0	0	2,603	0	6,953
2017	7,224	4,526	717	892	0	0	2,603	0	0
2018	0	0	1,576	0	6,662	0	2,603	0	0
2019	0	0	0	0	8,445	0	2,603	0	0

[124] http://ethanolrfa.org/page/-/rfa-association-site/Industry%20Resources/RFA.Ethanol.Rail.Transportation.and.Safety.pdf?nocdn=1

Table TC4: Fleet Forecast DOT-111 and CPC-1232 from 2014-2034									
	DOT-111 Unjacketed		DOT-111 Jacketed		CPC 1232 Unjacketed		CPC-1232 Jacketed		Planned New Construction
2020	5,003	0	0	0	37	0	2,603	0	0
2021	8,739	7,192	0	0	0	0	2,603	0	0
2022	5,076	0	63	25	751	0	2,603	0	0
2023	20	0	0	0	0	0	2,603	0	0
2024	0	134	0	0	0	0	2,603	0	0
2025	0	0	0	0	0	0	859	0	0
2026	0	0	0	0	0	0	0	0	0
2027	0	0	0	0	0	0	0	0	0
2028	0	0	0	0	0	0	0	0	0
2029	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0
2033	0	0	0	0	0	0	0	0	0
2034	0	0	0	0	0	0	0	0	0

4. Cost Areas for Tank Car Options

This section presents the areas of costs associated with the proposed tank car options. The initiative would generate costs in the following areas:

- *Incremental cost of newly constructed tank cars*: the acquisition cost of the Option 2 design tank car option, compared to the baseline Enhanced Jacketed CPC-1232 tank car, was estimated at $2,000 at the NPRM stage. In comments to the docket, Greenbrier estimated that extra shell thickness would cost about $1,500 per 1/16th of an inch. Growth Energy derived an estimate that adding an extra eighth of an inch would cost $3,880 based on calculations used in the draft RIA. For this analysis we elected to use estimates provided by a tank car manufacturer. Since the new car standard is an eighth of an inch thicker than a CPC-1232J, this implies a cost differential of about $3,000 for shell thickness.
- *Cost for ECP Brake Equipment Additional Steel:* For the NPRM Option 1, we estimated a $5,000 cost differential at the NPRM stage. This included $3,000 for ECP equipment and $2,000 to increase shell thickness. It was assumed at the NPRM stage that rollover protection would cost as much as the current standard top fittings protection so no additional cost was attributed to rollover protection. Comments suggested that the costs for ECP, shell thickness, and rollover protection were higher than PHMSA initially estimated. From the comments, PHMSA obtained an estimated cost for rollover protection of $5,000 per car. In addition, PHMSA increased its estimated cost for installing ECP brakes on a new tank car to $7,800 from $3,000 in response to comments. Finally, as discussed above, the cost of extra shell thickness has increased by $1,000 from $2,000 to $3,000. This raises the NPRM Option 1 new car differential from $5,000 to

$14,800. This difference in costs between the two cars, multiplied by the forecast of newly constructed tank cars, reflects a societal cost;

- *New Car differential for NPRM Option 3*. Because this has become the standard car, the industry is manufacturing for HHFT service, no additional incremental costs is attributed to new cars built to this standard.
- *Cost to retrofit existing tank cars*: the cost of labor and materials needed to bring most of the existing fleet up to the standard specified by the relevant option. Full schedules of these costs for all options are presented further below.
- *Out-of-service costs*: in order to implement the retrofits necessary to bring an existing car up to the new standard, a car will need to be taken out of service and cleaned prior to the retrofit. The lost service value for the time needed to complete the retrofits, as well as the cleaning costs, are societal costs. Some retrofits may be conducted during decennial requalification; in these cases, the additional time beyond that normally required for a requalification is used to develop this cost.
- *Cost of retirements*: As noted above, the Agency has revisited its assumption that no cars would be retired from this service in the event of promulgation of a higher tank car standard. We estimate that some portion of the fleet will be retired from this service rather than retrofit. The cost of retiring a car is the cost of the lost service value for the car is remaining service life, minus the scrap value, plus the incremental cost of acquiring a new car to replace the retired car.
- *Costs resulting from increased weight:* the heavier tank cars will lead to increased fuel expenditures and more track maintenance. The added weight of the car would also likely result in additional fees established by the rail carrier.

5. Costs of the Final Rule Option

Unit Cost Estimates

This section presents unit costs used in the analysis to estimate the total costs for the above cost areas. We present a cost analysis of the final rule option, which serves as the basis for the analysis of the Options considered at the NPRM stage.

1. Incremental costs of Newly Constructed Tank Cars

The cost to manufacture a car to the Option 2 standard required by the final rule is estimated based on the sale price of other similar cars, consultation with PHMSA and FRA engineers, and comments received on the ANPRM. The Option 2 tank car standard adds several enhancements to a standard DOT-111 tank car, but only one additional safety feature in comparison to the enhanced CPC-1232J car – increased shell thickness. As a result, the marginal increase in the cost of the Option 2 car relative to a new CPC-1232J is the cost of adding an eighth of an inch of shell thickness: $3,000. The difference in costs between the Option 1 tank car and the Option 3

tank car is $14,800. This figure represents the incremental costs to a buyer who is required to purchase the Option 1 tank car instead of the Option 3 tank car. Relative to the Option 3 tank car, the Option 1 tank car includes:

- New ECP brakes ($7,800)[125]
- An additional 1/8-inch shell thickness ($3,000)[126]
- Roll-over protection $4,000 (relative to top fittings protection)

2. Cost of Retrofitting Existing Tank Cars

The estimated costs to retrofit the various configurations of current in-service tank cars came from comments submitted to the docket by RSI, Dow, Greenbrier, and several other industry commenters. Commenters provided detailed cost information on each of the enhancements necessary to bring older cars up to the new performance standard. These include the cost of top fitting protections, jackets, thermal protection, or replacement of the pressure relief valve, a new bottom outlet valve handle, full-height head shields, and truck upgrades.

Table TC5: Retrofit Costs for Public Comments

Retrofit Option	Cost
Bottom outlet valve handle	$1,200
Pressure relief valve	$1,500
Truck Upgrade	$12,000 (if needed)
Thermal protection, full jacket, and full height head shields	$27,400

We expect that tank cars will meet the Option 3 standard by adding a full 11-gauge jacket, full height head shields, thermal protection, and improved BOV handle and PRV.

NPRM Assumption: No new trucks needed. In consultation with FRA and PHMSA tank car engineers, we made modifications to the costs presented by Watco and RSI for the initial RIA. PHMSA worked under the assumption that the crude and ethanol fleet is relatively new, and that most cars in service were built in the past 15 years. This assumption and would have trucks rated to 286,000 pounds. RSI and other NPRM commenters argued that minor or major upgrades may still be needed for some portion of the fleet, though they were not specific as to how many cars would need upgrades. The only guidance we received on their cost was a provided range between $2,000 and $24,000.

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[125] Federal Railroad Administration, ECP Brake System for Freight Service, Final Report, Booz Allen Hamilton, released August 2006.

[126] The extra cost of increased thickness is based on the amount of steel that is required to be added to a shell/jacket, and a cost per pound of steel of $0.40 per pound. Source: http://www.metalprices.com/p/SteelBenchmarkerFreeChart

It is clear from the tare weight that only the DOT-111NJ should need truck upgrades. A non-jacketed CPC-1232 is heavier than a DOT-111NJ by virtue of having half-height head shields and a thicker shell. This car would have to be short loaded if rated to only 263,000 lbs. A DOT-111J and CPC-1232J would also have to be short loaded if rated to only 263,000 lbs. It seems unlikely that the industry would build a car to a weight rating that would force it to be chronically under-filled. As a result, we assume that only DOT-111s without jackets suffer from the wheel bearing/truck issue. As noted above, RSI presents a wide cost range for upgrading the trucks on these cars. We assume the average retrofit cost for truck upgrades would fall in the middle of this range, or $12,000 per car. This is intended to be an average cost; modifications for some cars may cost more than this, and modification of others may be less.

As noted elsewhere, we have assumed that 28 percent of cars in crude and ethanol service will be retired based on RSI's comments. We assume these cars are the ones that would require the most costly truck upgrades. In addition, the retrofit standard adopted for the final rule results in a lighter car because no increase in shell thickness is required.

Cost of a full-height head shield is included in $23,400 jacket cost. All non-jacketed retrofit cars will have to have jackets and thermal insulation applied to meet the puncture resistance and survivability standards established by this rule. We assume no car would have to have full height head shields mounted directly on the body—the cost of new head shields is built into the cost of a jacket. Comments from Watco at the NPRM stage indicated that head shields are commonly built into jackets and this reduces the cost of applying full height head shields to a car substantially. RSI argued in comments to the NPRM that head shields cost $20,000 and a jacket costs another $16,000. In contrast, Dow presented costs for full height head shields, thermal protection, and a jacket that were less than RSI's estimated cost for a jacket alone – $15,000 - $20,000. As presented above in the itemized cost table, we use a cost of $27,400 for a jacket, full height head shields, and thermal protection. This is substantially more than Dow's estimate but less than RSI's estimate. It is close to the cost used in the initial RIA.

No required top fittings for retrofitted tank cars. In addition, as noted in the preamble and above, retrofit requirements do not mandate top fittings protection, so those costs are omitted from the analysis. All the other tank car models described here have top fittings protections (or rollover protection) as a standard feature.

We expect the non-jacketed DOT-111, the jacketed DOT-111, and the non-jacketed CPC1232 to be retrofitted. The cost of upgrading a non-jacketed DOT-111 to the option 3 tank car standard is presented in the table below. We assume some level of cost savings due to returns to scale, bulk purchasing, and learning curve efficiency improvements given the volume of retrofits, so we apply 10 percent cost reduction factor.

Table TC6: Retrofit Costs for the Non-Jacketed DOT-111 (Option 3 Tank Car)

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Truck upgrade	$12,000

Full jacket + full height head shields retrofit cost	$23,400
Unadjusted Total	**$42,100**
Learning curve cost reduction	10%
Adjusted Total	**$37,890**

The Agency assumes that the CPC-1232NJ would be retrofit by removing the half height head shields that come standard on this car and applying an 11- gauge jacket with full height head shields and thermal protection. It must be noted that the CPC-1232NJ has an 8/16ths inch shell – thicker by a sixteenth of an inch than the CPC-1232J. In theory, this car would meet the retrofit standard with a thinner than normal jacket, but PHMSA assumed the industry would not build a separate jacket for these cars and would apply the standard 11- gauge jacket. As a result of their thicker shell, with the jacket and full height head shields, this car would exceed the safety performance of the CPC-1232J retrofit standard.

Table TC8: Retrofit Costs for the Jacketed DOT-111 (Option 3 Tank Car)

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Truck Upgrade	$0
Full jacket + full height head shields retrofit cost	$23,400
Unadjusted Total	**$30,100**
Learning curve cost reduction	10%
Adjusted Total	**$27,090**

Table TC9: Retrofit Costs for the Non-Jacketed, DOT CPC-1232NJ (Option 3 Tank Car)

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost with half height head shields	$23,400
Unadjusted Total	**$30,100**
Learning curve cost reduction	10%
Adjusted Total	**$27,090**

Table TC10: CPC-1232J to Enhanced CPC-1232J

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Unadjusted Total	**$2,700**
Learning curve cost reduction	10%
Adjusted Total	**$2,430**

3. Out of Service Costs (Lost Service Value)

PHMSA used a rental price of capital approach to estimate the service value of the tank cars; these values are used to develop cost estimates for taking cars out of service to retrofit them. The approach takes into account depreciation and the opportunity costs of the asset, amortizing the acquisition costs over the average life span of the cars. PHMSA assumed a 7 percent interest rate, and 40 and 50-year life spans for the DOT-111s and CPC-1232s respectively. The acquisition cost of the non-jacketed DOT-111 was assumed to be $60,000, and the non-jacketed CPC-1232s being $85,000. These assumptions produce the annual service values listed in the table below.

PHMSA also estimated that retrofitting DOT-111 cars would take an average of 12 weeks, and retrofitting CPC-1232 cars would take 8 weeks. As shown below, the annual values presented above are prorated accordingly and used to value the lost service time.

Table TC11: Value of Lost Service

Tank Car	Annual Service Value	Time Out-Of-Service from Retrofits	Total Lost Service Value from Retrofits
DOT-111NJ	$4,474	12 weeks	$1,033
CPC-1232 NJ	$6,137	8 weeks	$944
DOT-111J	$4,474	8 weeks	$944

Several commenters argued for higher out of service costs based on reported lease rates (lease rates at the time ranged from $1,400 per month to $4,500 per month). This was a dramatic increase from $400 per month lease rates reported in 2010. It appears that these lease rates reflect unusually high demand for rail tank cars set off by the sharp increase in the volumes of crude oil being transported by rail. Since the time those comments were made there have been deliveries of new tank cars as the new tank cars are delivered we expect lease rates to return to historic norms.

Costs Resulting from Increased Weight

PHMSA and FRA received numerous comments from stakeholders indicating that the increased weight of the shields, TPS, jackets, brakes, valves, fittings, etc. would decrease the carrying capacity of the tank car. Some of the commenters even calculated that they would need to increase their fleet by 9 percent in order to account for the lost capacity. Many commenters focused on CPC 1232 tank cars, in particular, as being potentially affected by the weight of the safety features that would be added during retrofitting. For instance, the Brattle Group submission on behalf of RSI indicated that because some unjacketed CPC 1232 tank cars are already built to 286,000 lbs. GRL, the added weight from a retrofit will decrease carrying capacity. API and AFPM provided similar comments. Bridger commented that the decreased volume capacity for tank cars resulting from the rule would result in shippers and marketers securing more railcars and trains to haul its domestic production to market, contributing to increased congestion on the rails. Hess commented that the proposed Option 2 cars would result in a capacity loss of 2,127 gallons for each of its current CPC-1232 non-jacketed cars, which it states have a tare weight of 74,300 lbs. and shell capacity at 1 percent outage of 30,888 gallons.

PHMSA and FRA disagree with public commenters' claims that the rule will necessarily reduce the load limit (i.e. the weight of the lading) of current and future crude and ethanol tank cars in the absence of this rule, and consequently disagrees with the claim that the increased tare weight will necessitate an increase in the number of carloads required to move a given amount of product. The maximum allowable GRL is 286,000 pounds. PHMSA and FRA believe that, for all but an inconsequentially small number of such tank car loads, the difference between the current weight of a loaded car using standard operating practices and 286,000 lbs. is more than the weight that will need to be added to comply with this rule. This is true for both the current crude and ethanol fleet and new tank cars (including jacketed and non-jacketed CPC-1232 cars) as they would have been placed into this service over the next 20 years in the absence of this rule. Therefore, the vast majority of tank cars will be able to comply with this rule without realizing any meaningful loss in capacity. Consequently we have not accounted for any capacity losses in our analysis.

There are five areas of evidence that PHSMA and FRA rely on to address this concern. First the unit weight of crude oil can vary. The unit weight of crude oil used in this analysis was randomly selected from analytical results from DOT's Operation Classification. One of the comments used a weight of 6.78 lbs/gallon. As this is a valid weight, we acknowledge that there may be lading loss for the heaviest materials. PHMSA and FRA calculated that there will be no loss of innage for crude oil with a unit weight of 6.7 pounds per gallon which is on the high end of the weight of crude oil. 6.56 lbs/gallon is an accurate estimate for light crude. Our calculation also assumes that shippers are loading the materials at the 115F reference temperature (load to the 99% innage). This will be discussed later in this document–we anticipate that there will not be a net loss of material moved because the existing tank cars are currently operating below the maximum gross weight on rail.

Second, the tare weight of the tank cars used to transport Bakken crude range from approximately 66,000 pounds to 95,000 pounds, with the vast majority being at the lower end of the range. Below, PHMSA and FRA have provided the calculations for the increase in weight from all the safety features in this final rule.

Additional Thickness

Unit weight of steel – approximately 492 lbs/cubic foot

Surface area of 2:1 ellipsoidal heads – 217 square foot (sf)
Surface area of 10' diameter shell – 1500 sf
Additional thickness 1/16" = 2.56 lbs./sf
Additional weights for head/shell – 1,717 sf x 2.56 lbs./sf = 4,396 lbs.

Jacket and Headshield

Jacket diameter – 10.66" (allow for 4" of annular space) – This is likely an over estimation because of Plate C clearance restrictions)
Length of shell - 48.41'
Surface area of shell – 1,621 sf
Additional weight of jacket (0.1196") – 1,621 x 4.9 lbs./sf = 7,943 lbs.
Surface area of 2:1 ellipsoidal heads (0.5" thick) - 239 sf x 20.5 lbs./sf – 4,900 lbs.

Total weight for additional thickness, jacket and head shield – 17,239 lbs.

To be conservative, if we added 4,000 pounds for top fittings protection (the top fittings protection would not apply to retrofitted tank cars), the total weight of the enhancements would be 21,239 pounds. As calculated, these safety enhancements have increased the tare weight by approximately 23,000 pounds, which assumes 1,761 pounds for thermal protection and jacket standoffs. The allowable gross rail load is 286,000 pounds (23,000 pounds greater than 263,000 pounds). So, there is not net gain/loss of load limit. These calculations look at retrofitting a DOT 111 to a DOT 117.

If a CPC-1232 is upgraded, its tare weight would be close to that of the DOT 117, calculated above. An unjacketed CPC 1232 built to 286,000 lbs. GLR with a 30,000 gallon tank is estimated to have a tare weight of 74,000 lbs. The added weight from the retrofit requirements is less than that from the new tank car requirements estimated above. The features are a combined 10,893 lbs. (2,450 lbs. for the head shields, and 500 lbs. for jacket stand-offs and 7,943 pounds for a jacket). This brings the total tare weight of the car to 84,893 lbs., which leaves 201,107 lbs. for the load. At 6.7 lbs. per gallon, crude oil that is on the heavier end would weigh 198,990 lbs. when filled to allowable innage (29,700 gallons at 6.7 lbs. per gallon), which means that a fully loaded 117R that was originally an unjacketed CPC 1232 would be under the GRL. As discussed below, the lading temperature and typical operating practices for innage indicate that even 198,990 lbs. of lading is more than is typical.

Third, the majority of the cars in crude oil and ethanol service have a nominal 30,000 gallon shell full capacity. Some of the commenters' tank cars were constructed with a shell full capacity of 31,700 gallons, which is not the typical tank car. This additional capacity, relative to the more common tank car with a nominal shell full capacity of 30,000 gallons, adds 1,000-2,000 pounds to the tare weight. However, those cars are outliers. Assuming the tare weight and shell capacity estimates provided by Hess for its unjacketed CPC-1232 cars are accurate, Hess may experience a reduction in load limit. After retrofitting one of Hess's cars, the tare weight would be 85,193 lbs. (74,300 lbs. + 10,893 lbs. = 85,193 lbs.). Hess asserts that its cars can carry 206,950 lbs. of certain crude oil (30,888 gallons x 6.7 lbs. per gallon = 206,950 lbs.). The post-retrofit tare weight of these cars plus the weight of the current carrying capacity of these cars is 292,143 lbs., which exceeds the 286,000 GRL by 6,143 lbs (85,193 lbs. + 206,950 lbs.). However, when calculated using the typical outage used in the industry of 3-9% (see below), the weight of crude oil using 6.7 lbs. per gallon would be between 190,226 lbs. (28,392 gallons x. 6.7 lbs. per gallon) and 202,769 lbs., which would make the post-retrofit tare weight of these cars plus the weight of the current carrying capacity between 275,419 and 287,962 lbs. (30,264 gallons x 6.7 lbs. per gallon). Further, the weight used for crude oil in this analysis is conservative in that it uses a value of 6.7 lbs. per gallon, which is on the high end for crude oil. Thus, even for these large cars, reduced carrying capacity is not expected to be a significant issue. Finally, PHMSA and FRA believe Hess cars are an outlier.

Fourth, in order to comply with the Federal regulation an offeror must ensure that the outage in the tank would not be less than 1% (or 99% innage) at a lading temperature of 115F (for tank cars without insulation and/or thermal protection). Accordingly, they must measure or estimate the unit weight of the material at 115F. With this information they can calculate the weight that can be put into the tank without the volume exceeding the maximum innage of 99%. Because

most liquids expand upon heating, the unit weight of the lading at a lower temperature will be lower than at higher temperature. So less lading can be put into the tank.

Surprisingly, most, if not all, shippers of crude oil do not know the unit weight of the lading in each tank car at a reference temperature (115F) so they short load the tank. Based an audit of loading facilities in the Bakken, most offerors require a minimum of 3-5% outage after the tank has been loaded. Additionally, based on information obtained during Operation Classification, it was learned that the actual outage in tank car ranges from 3-9%. Short loading ensures a shipper that the tank car is in compliance with current regulations. However, as shippers are required to know the reference temperature of the commodity shipped, tank cars should be loaded to 99% innage. The DOT 117 cars are expected to permit the same capacity when transporting these commodities as the shippers are currently getting, assuming the shipper follows the current federal regulations and load to 99% innage.

Finally, with thermal protection and/or insulation, more lading can be placed in the tank (because of the lower reference temperatures be can be loaded into the tank). Tank cars without insulation and/or thermal protection cannot be loaded in excess of 99% innage at a reference temperature of 115F. For thermally protected tank cars the reference temperature is 110F, and for insulated tank cars the reference temperature is 105F. The vast majority of tank cars used to transport crude oil are currently not equipped with thermal protection or insulation so their reference temperature is 115F. The greater the temperature, the lower the unit weight and the lower the weight of lading that can be placed in the tank.

In conclusion, PHSMA and FRA recognize that some outliers in the crude and ethanol fleet may have a reduction in capacity due to their abnormal shell capacity or particularly high weight of the crude oil that they are shipping. However, PHMSA has not included the impacts to these outliers in its estimates of the rule's benefits and costs. PHSMA and FRA are confident that the bulk of the HHFT fleet will be able to transport the same amount of product as they are currently shipping.

PHMSA expects increased weight would have two primary effects: 1) increase in fuel expenses and 2) increase in repair and maintenance expenses, including track maintenance.

To estimate the increase in fuel expenses required for the additional weight of the retrofits, PHMSA developed an estimate of rail fuel expenditures per ton-mile. To develop the estimate, PHMSA relied on CSX data indicating that the railroads can move a ton of freight 450 miles using one gallon of fuel,[127] or that one ton-mile requires 1/450 gallons of fuel. To value this

[127] See http://www.csx.com/index.cfm/about-csx/projects-and-partnerships/fuel-efficiency/

figure, PHMSA assumed an average retail price for diesel of $2.83 per gallon[128]—$3.14 reduced by 10 percent to allow for bulk purchase discounts. The resulting cost per ton-mile is estimated to be $0.0063.[129]

To estimate the increase in repair and maintenance expenses resulting from the additional weight of the retrofits, PHMSA developed an estimate of the railroads repair and maintenance expenditures per ton-mile. Operating expenditures by the railroads were obtained from STB's *Statistics of Class I Railroads*. PHMSA used the repair and maintenance line items for rails and tracks, ties, bridges and culverts, roadways, and tunnels and subways. These expenses were then divided by total freight ton-miles in the U.S. This was estimated using the rail public waybill data, and inflated to 2013 using BLS' producer price index for railroads. The cost per ton-mile is estimated to be $0.000826.

Table TC13: Increased Fuel and Maintenance Costs

Tank Car	Increased weight to achieve PHMSA and FRA designed car standard (tons)	Miles Per Year, Per Car	Additional Fuel Costs per Ton-Mile	Additional Maintenance Cost per Ton-Mile	Annual Additional Fuel and Maintenance Costs
Retrofitted Non-Jacketed DOT-111	8	15,400	$0.0063	$0.00083	$878
Retrofitted Jacketed DOT-111	2.5	15,400	$0.0063	$0.00083	$275
Retrofitted Non-Jacketed CPC-1232	4.75	15,400	$0.0063	$0.00083	$522
Enhanced Jacketed CPC-1232	0	15,400	$0.0063	$0.00083	$0
Replacement of jacketed CPC-1232 with Option 2 New construction	2.25	15,400	$0.0063	$0.00083	$247
Replacement of retired unjacketed DOT-111 with	10.25	15,400	$0.0063	$0.00083	$1,125

[128] Energy Information Administration. Gasoline and Diesel Fuel Update. Weekly price of diesel for week ending 2/2/2015AvailableAvailable online at http://www.eia.gov/petroleum/gasdiesel/

[129] Extra ton-miles total 77.6 billion over 20 years. The associated cost was calculated as follows: Each car is estimated to make nine 1,100 mile trips per year. The cost of extra fuel is calculated by multiplying the number of trips (14) by the miles per trip (1,100) by the average extra weight per car (2.25 – 10.25 tons) by the cost of fuel per ton mile ($0.0063) or extra maintenance ($0.00083) by the number of cars.

Table TC13: Increased Fuel and Maintenance Costs					
Option 2 New Car					
Replacement of retired jacketed DOT-111 with Option 2 New Car	4.75	15,400	$0.0063	$0.00083	$522

Costs of Retiring Older Tank Cars

In response to public comments and in light of conversations with Transport Canada, PHMSA has included costs of retiring older DOT-111 tank cars early, rather than assuming that they would be repurposed for oil sands service. Comments submitted by RSI indicate that they estimate that 28 percent of DOT-111s will be retired early because of this rule. PHMSA has reviewed this estimate, and data on the distribution of DOT-111 tank car ages from Umler[130] supports this estimate.

PHMSA views an owner's decision to retire a rail tank car early as an evaluation of the tradeoff between bearing the cost of retrofitting the tank car, and replacing that tank car before the end of its normal service life. PHMSA assumed that the cost of early replacement would be the difference in the purchase prices of a new rail tank car today versus the discounted (at a 7 percent rate) cost of purchasing a rail tank car in the future (at the normal end of the service life of the car it is replacing). In addition, PHMSA assumed that tank car owners would be able at least to sell retired rail tank cars for scrap metal.

PHMSA used the following parameters in conducting this analysis:

1) A new rail tank car that is compliant with this rule will cost $130,000.
2) The tare weight of an unjacketed DOT-111 is 67,800 lbs. (30,754 kg), and the tare weight of a jacketed DOT-111 is 72,400 lbs. (32,840 kg).
3) The price of bulk scrap steel is approximately $400 per metric ton.[131] Consequently, a scrapped unjacketed DOT-111 is worth approximately $12,300, and a scrapped jacketed DOT-111 is worth approximately $13,100.

[130] "The Umler® system is an electronic resource that contains critical data for North American transportation equipment. Originally created in 1968, Umler maintains data for more than two million pieces of equipment used in rail, steamship and highway service." See: https://www.railinc.com/rportal/umler-system.

[131] There are multiple sources for these prices, which vary daily and by region. Data from the London Metal exchange (http://www.lme.com/en-gb/metals/steel-billet/) indicate that steel billet is currently priced around $500 per metric ton (as-of January 16, 2015). Research has indicated scrap steel tend to follow, but are marked below,

4) As follows from parameters 1) and 3), the net purchase cost for purchasing a rail tank car to replace:
    a. An unjacketed DOT-111 is $117,000 ($130,000 − $12,300)
    b. A jacketed DOT-111 is $116,900 ($130,000 − $13,100)
5) Materials and out-of-service costs for an unjacketed DOT-111 retrofit are estimated to be $38,923. Those costs for a jacketed DOT-111 retrofit are $28,123.

Parameters 4) and 5) allow an estimate of the number of years at which a tank car owner would be indifferent with respect to the cost of retrofitting a DOT-111 and purchasing a replacement tank car early. Specifically:

1) $Non-Jacketed\ DOT-111$: $117,700 – ($117,700 ÷ (1.07Y)) = $38,923. Where: solving for Y yields approximately 5.9 years of remaining service life. This number of years represents the boundary for remaining service life. Rail tank cars that are retired early will have at most this number of years remaining. Many cars will actually have fewer years left.
2) *Jacketed DOT-111*: $116,900 – ($116,900 ÷ (1.07Y)) = $28,123. Solving for Y yields about 4.1 years of remaining service life.
3) PHMSA analyzed Umler data on tank car ages[132] and determined that the weighted average remaining service years for unjacketed DOT-111s with 5.4 years or less of remaining service life was 1.9 years. For jacketed DOT-111s with 3.7 years or less of remaining service life, it was 1.3 years. The weighted average number of years foregone is used for the value of Y in the following equations, which are used to calculate the average cost of early retirement.
4) *Non-Jacketed DOT-111*:
   $117,700 – ($117,700 ÷ (1.07 ∗ 1.9)) = $14,167 Average cost of early retirement.
5) *Jacketed DOT-111*:
   $116,900 – ($116,900 ÷ (1.07 ∗ 1.3)) = $11,297 Avg. cost of early retirement.

Development of Total Cost

In this section, PHMSA combined the per unit cost estimates with quantity estimates to produce total costs estimates for the different cost factors.

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these prices. Consequently, it has used an estimate of $400 per metric ton. Prices posted online by numerous scrap metal buyers conform to this estimate.

[132] The Umler Equipment Management Information System is the rail Equipment Register for North America. We used data on equipment age for this analysis.
https://www.railinc.com/rportal/alf_docs/UmlerReference/UmlerDataSpecs.pdf.

There is a relationship between retrofitting costs, new construction costs, out-of-service costs and lost value of service; therefore, it is necessary to present these costs as a group, together with the methodology used to develop them.

Timing Assumptions

The schedule for when retrofits have to be completed is presented in the table below. Based on comments, we assume that the industry would need a 6 month ramp-up in order to prepare to begin retrofitting cars, and after that, they would retrofit legacy DOT-111s to capacity until work is complete.

Retrofit Schedule		
Tank Car Type / Service	**Fleet Size**	**DOT Revised Schedule**
Non Jacketed DOT-111 tank cars in PG I service	11,637	**(January 1, 2017)**[133] **January 1, 2018**
Jacketed DOT-111 tank cars in PG I	2,268	**March 1, 2018**
Non Jacketed CPC-1232 tank cars in PG I service	15,144	**April 1, 2020**
Non Jacketed DOT-111 tank cars in PG II service	18,493	**May 1, 2023**
Jacketed DOT-111 tank cars in PG II service	88	**May 1, 2023**
Non Jacketed CPC-1232 tank cars in PG II service	751	**July 1, 2023**
Jacketed CPC-1232 tank cars in PG I and PG II service* and all remaining tank cars carrying PG III materials in an HHFT (pressure relief valve and valve handles).	24,993	**May 1, 2025**

Methodology

To facilitate the calculations, the same methodology was used to develop estimates for the following four groups:

- Jacketed Ethanol Fleet
- Jacketed Crude Oil Fleet

[133] The January 1, 2017 date would trigger a retrofit reporting requirement, and tank car owners of affected cars would have to report to DOT the number of tank cars that they own that have been retrofitted, and the number that have not yet been retrofitted.

- Non-Jacketed Ethanol Fleet
- Non-Jacketed Crude Oil Fleet

The methodology consists of the following steps.

1) ***Calculate the Cost of New Construction for Non-Replacement Growth*:** The demand for new tank cars is based on two sources: replacement investment and new investment. Replacement investment occurs when companies purchase a new car to replace one they are transferring to a different service. New investment occurs when companies increase the size of their fleet to accommodate growth in the markets they serve. Replacement investment was addressed in Step 1 above. New investment was calculated in a similar fashion. Again, PHMSA assumed that all buyers would have purchased Option 3 car instead of the Option 1 car. For each year in the forecast horizon PHMSA multiplied the expected number of new tank cars by the incremental acquisition cost of $3,000.
2) ***Calculate Retrofitting Costs:*** For the retrofitting costs, PHMSA used the unit cost presented in the table titled, "Retrofitting Costs by Car Type," combined with cost estimates for taking the cars out-of-service to conduct the retrofits. For instance, for the DOT-111 NJ the retrofit cost of $38,923 per retrofit, including unit costs ($37,890) and out of service costs ($1,033) is multiplied by the number of cars retrofit per year to obtain a total cost for upgrading those cars in each year.

   For the unit costs, PHMSA took the adjusted totals presented in Tables TC8 and TC9. For the out-of-service costs, as explained above and shown in Table TC10, PHMSA divided the values in the table titled "Annual Service Values per Car" by 52 to put them on a weekly basis, and then multiplied them by the estimated number of weeks needed to conduct the retrofits (12 weeks for non-jacketed DOT-111s, 8 weeks for non-jacketed CPC-1232s). Thus, PHMSA calculated that non-jacketed DOT-111 cars would have an out-of-service cost of $1,033. PHMSA calculated that non-jacketed CPC-1232 cars would have an out-of-service cost of $944.

3) ***Compute Total Increased Operating Expenditures:*** Total increased operating expenditures resulting from the increased weight of the retrofits were estimated for fuel and for repair and maintenance. The cost estimates were developed by multiplying the number of retrofitted tank cars operating each year by the per-unit costs, the additional weight of the retrofits (in tons), the average number of carloads per tank car, and an estimate of the average miles per carload. The average number of carloads per tank car was estimated by dividing total crude oil and ethanol carloads (from the waybill) by the respective fleet size. Estimates for average miles per carload were developed using the waybill data. As shown in Table TC 12, this methodology generates an increase in annual operating expenditures of $1,019 for retrofitted non-jacketed DOT-111 tank cars (starting in 2018), $641 for retrofitted non-jacketed CPC-1232 cars (starting in 2018), and $256 for newly constructed cars (starting in 2016).
4) ***Compute Cost of Retirements*:** Multiply the number of retired DOT-111 NJ tank cars (11,851) by the cost of retirement, $14,167. Multiply the number of retired DOT-111 J tank cars (916) by the cost of retiring the DOT-111 NJ, $11,297.
5) ***Calculate Present Values:*** The yearly costs over the forecast horizon were converted to present values using a 7 percent discount rate and 3 percent discount rate.

Cost Estimates Inputs and Sources

The following table summarizes the key inputs and sources for our total cost estimates:

Table TC15: Final Rule Tank Car Option: Enhanced Jacketed CPC-1232 retrofit with NPRM Option 2 New Car Standard		
Variable	**Formula/Input**	**Source**
Number of **DOT-111NJ Retrofitted** 2016-2018	30,130 tank cars	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Non-Jacketed	$37,890	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of DOT-111 Non-Jacketed	$1,033	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232 (based on 8.93 tons of extra weight)	$878	DOT Adaptation of EIA and CSX Corporation Data
Number of **DOT-111 Jacketed Retrofitted** 2016-2018	2,356	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Jacketed	$27,090	DOT estimate and comments from Watco
Time Out-of-Service Cost of DOT-111 Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232	$275	DOT Adaptation of EIA and CSX Corporation Data
Number of CPC-1232NJ 2021-2025	20,194 tank cars	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Non-Jacketed	$27,090	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of CPC-1232 Non-Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232 (based on 4.5 tons of extra weight)	$522	DOT Adaptation of EIA and CSX Corporation Data
Number of **CPC-1232 Jacketed Retrofitted** 2016-2018	34,331	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Jacketed	$2,430	N/A
Time Out-of-Service Cost of CPC-1232 Jacketed	N/A	N/A
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232	N/A	N/A

Table TC15: Final Rule Tank Car Option: Enhanced Jacketed CPC-1232 retrofit with NPRM Option 2 New Car Standard		
Variable	**Formula/Input**	**Source**
Number of **New NPRM Option 2 Cars Constructed for fleet growth**, 2015-2019	6,953 tank cars	DOT Estimate
Incremental Cost of DOT-117, Relative to Enhanced Jacketed CPC-1232	$3,000	N/A
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Number of DOT-111 NJs retired rather than retrofit.	11,8511tank cars	DOT Estimate
Cost of retiring DOT-111 NJ	$14,167	N/A
Fuel and maintenance cost of replacing a retired car	$247	N/A
Number of **New DOT-117 Cars Constructed for retirement of DOT-111J**, 2015-2019	916 tank cars	DOT Estimate
Incremental Cost of Retiring DOT-111 J	$11,297	N/A
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Additional Fuel and Maintenance Costs Per Year for replacing retired car	$247	N/A

6. Total Costs for Final Rule Option

The table below presents the total estimated 20-year costs for the option implemented by the accompanying final rule.

	DOT 111 Unjacketed		DOT 111 Jacketed		CPC 1232 Unjacketed	CPC 1232 Jacketed	**Total**		**Planned New Construction (Additional Cost)**	**Fuel and track Maintenance**
Year	Retrofits	Retirements*	Retrofits	Retirements*	Retrofits	Retrofits	**Retrofits**	**Retirements***	**New Construction**	**Fuel and track Maintenance**
2015	$0	$0	$0	$0	$0	$2,195,301	$2,195,301	$0	$0	$0
2016	$171,767,199	$0	$0	$0	$0	$8,781,205	$180,548,404	$0	$20,859,000	$5,594,220
2017	$281,179,752	$64,112,759	$20,164,191	$10,073,786	$0	$8,781,205	$310,125,148	$74,186,544	$0	$17,695,120
2018	$0	$0	$44,321,848	$0	$186,762,508	$8,781,205	$239,865,561	$0	$0	$21,602,369
2019	$0	$0	$0	$0	$236,747,130	$8,781,205	$245,528,335	$0	$0	$26,006,939
2020	$194,731,769	$0	$0	$0	$1,037,258	$8,781,205	$204,550,232	$0	$0	$30,420,952
2021	$340,148,097	$101,885,129	$0	$0	$0	$8,781,205	$348,929,302	$101,885,129	$0	$46,191,501
2022	$197,573,148	$0	$1,771,749	$276,777	$21,053,534	$8,781,205	$229,179,636	$276,777	$0	$51,072,104
2023	$768,729	$0	$0	$0	$0	$8,781,205	$9,549,934	$0	$0	$51,089,452
2024	$0	$1,899,362	$0	$0	$0	$8,781,205	$8,781,205	$1,899,362	$0	$51,240,344
2025	$0	$0	$0	$0	$0	$2,897,798	$2,897,798	$0	$0	$51,240,344
2026	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2027	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2028	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2029	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2031	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2032	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2033	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
2034	$0	$0	$0	$0	$0	$0	$0	$0	$0	$51,240,344
NPV 7%	$836,547,207	$116,749,585	$51,304,086	$8,384,297	$324,222,172	$56,897,181	$1,268,970,646	$125,133,882	$18,219,058	$369,902,036
NPV 3%	$1,015,437,919	$142,927,493	$59,231,114	$9,437,431	$387,644,765	$70,604,808	$1,532,918,606	$152,364,924	$19,661,608	$568,965,483

The total 20 year costs of the new tank car standard adopted in the accompanying final rule are $1.782 billion using a 7 percent discount rate, and $2.274 billion using a 3 percent discount rate.

Costs of Enhanced CPC-1232 Standard (Option 3)

PHMSA also considered another standard that mandates all cars to meet or exceed the performance achieved by an Option 3 tank car. This car is already in production and is the standard the tank car manufacturers have committed to build to for flammable liquid unit train service. The costs for mandating this standard are developed in this section. The cost analysis is similar to that for the Option 1, with the following changes:

- Our baseline assumption is that this car would be the car that is produced in the in absence of regulation. As a result, we assume no incremental costs associated with building new cars to satisfy growing demand for tank cars to ship crude oil and ethanol in unit trains.
- The retrofit costs for the DOT-111NJ, DOT-111J, and CPC-1232NJ would be the same as the retrofit costs estimated for the final rule, because the Option 3 tank car is the retrofit standard for the final rule.
- The additional fuel and maintenance costs would be the same for retrofitted cars, but newly constructed cars would not impose these costs, because the Option 3 tank car would be the newly built car regardless.

We continued all other assumptions listed in the cost analysis for the final rule option car. The table below summarizes the information that feeds into the cost analysis for this tank car option.

Table TC16: Retrofit Costs for the Non-Jacketed DOT-111 (Option 3 Tank Car)	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Truck Upgrade	$12,000
Full jacket + full height head shields retrofit cost	$23,400
Unadjusted Total	**$42,100**
Learning curve cost reduction	10%
Adjusted Total	**$37,890**

Table TC17: Retrofit Costs for the Jacketed DOT-111 Tank CAR (Option 3 Tank Car)	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost with half height head shields	$23,400
Unadjusted Total	**$30,100**
Learning curve cost reduction	10%
Adjusted Total	**$27,090**

Table TC18: Retrofit Costs for the Non Jacketed DOT-111 Tank Car (Option 3 Tank Car)	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost with half height head shields	$23,400
Unadjusted Total	**$30,100**
Learning curve cost reduction	10%
Adjusted Total	**$27,090**

Table TC19: Retrofit Costs for the Jacketed CPC-1232J Option 3 Tank Car	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Unadjusted Total	$2,700
Learning curve cost reduction	10%
Adjusted Total	**$2,430**

Table TC20: Summary of Cost Estimates for an Option 3Tank Car					
Tank Car	**Increased weight to achieve PHMSA and FRA designed car standard (tons)**	**Miles Per Year, Per Car**	**Additional Fuel Costs per Ton-Mile**	**Additional Maintenance Cost per Ton-Mile**	**Annual Additional Fuel and Maintenance Costs**
Retrofitted Non-Jacketed DOT-111	8	15,400	$0.0063	$0.00083	$878
Retrofitted Jacketed DOT-111	2.5	15,400	$0.0063	$0.00083	$275
Retrofitted Non-Jacketed CPC-1232	4.75	15,400	$0.0063	$0.00083	$522
Enhanced Jacketed CPC-1232	0	15,400	$0.0063	$0.00083	$0
Replacement of jacketed CPC-1232 with Option 3 New construction	0	15,400	$0.0063	$0.00083	$0
Replacement of retired unjacketed DOT-111 with an Option 3 New Car	8	15,400	$0.0063	$0.00083	$878
Replacement of retired jacketed DOT-111 with an Option 3 New Car	2.5	15,400	$0.0063	$0.00083	$275

TC21: Summary of Cost Estimates for an Option 3 Tank Car Enhanced Jacketed CPC-1232 Car		
Variable	**Formula/Input**	**Source**
Number of DOT-111NJ Retrofitted 2016-2018	30,130 tank cars	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Non-Jacketed	$37,890	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of DOT-111 Non-Jacketed	$1,033	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232 (based on 8.93 tons of extra weight)	$878	DOT Adaptation of EIA and CSX Corporation Data
Number of DOT-111 Jacketed Retrofitted 2016-2018	2,356	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Jacketed	$27,090	DOT estimate and comments from Watco

TC21: Summary of Cost Estimates for an Option 3 Tank Car Enhanced Jacketed CPC-1232 Car		
Variable	**Formula/Input**	**Source**
Time Out-of-Service Cost of DOT-111 Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232	$275	DOT Adaptation of EIA and CSX Corporation Data
Number of New NPRM Option 2 Cars Constructed for fleet growth, 2015-2019	6,953 tank cars	DOT Estimate
Incremental Cost of CPC-1232 Jacketed, Relative to Enhanced Jacketed CPC-1232	$3,000	N/A
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Number of New NPRM Option 2 Cars Constructed for retirement of DOT-111NJ, 2015-2019	11,717 tank cars	DOT Estimate
Incremental Cost of Option 2 car Relative to Enhanced Jacketed CPC-1232	$14,167	N/A
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Additional Fuel and Maintenance Costs Per Year for replacing retired car	$247	N/A
Number of DOT-111 Jacketed Retrofitted 2016-2018	2,536	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Jacketed	$27,090	DOT estimate and comments from Watco
Time Out-of-Service Cost of DOT-111 Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to Enhanced Jacketed CPC-1232	$275	DOT Adaptation of EIA and CSX Corporation Data
Tank Car Capacity Loss from Enhanced Tank Car Standards	None	DOT Estimate
Number of DOT-111 NJ Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	11,851	DOT Estimate
Cost per retired tank car	$14,167	DOT Estimate
Number of DOT-111 J Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	918	
Cost per retired DOT-111 J tank car	$11,297	

TC21: Summary of Cost Estimates for an Option 3 Tank Car Enhanced Jacketed CPC-1232 Car		
Variable	**Formula/Input**	**Source**
Percentage of Track Capable of Handling 286,000 pounds of Gross Rail Load (GRL)	100%	DOT Estimate
Percentage of DOT-111 Non-Jacketed and CPC-1232 Non-Jacketed in PG II and PG III service	100%	DOT Estimate

Tables TC21 and TC22 summarize the 20-year cost streams for the Option 3 tank car. The first table presents undiscounted costs, the second costs discounted at a 7 percent discount rate.

TC22: Costs for the Option 3 Tank Car

	DOT 111 Unjacketed		DOT 111 Jacketed		CPC 1232 Unjacketed	CPC 1232 Jacketed	**Total**		**Planned New Construction (Additional Cost)**	**Fuel and track Maintenance**
Year	Retrofits	Retirements*	Retrofits	Retirements*	Retrofits	Retrofits	**Retrofits**	**Retirements***	**New Construction**	**Fuel and track Maintenance**
2015	$0	$0	$0	$0	$0	$2,195,301	$2,195,301	$0	$0	$0
2016	$171,767,199	$0	$0	$0	$0	$8,781,205	$180,548,404	$0	$20,859,000	$3,876,450
2017	$281,179,752	$64,112,759	$20,164,191	$10,073,786	$0	$8,781,205	$310,125,148	$74,186,544	$0	$14,639,001
2018	$0	$0	$44,321,848	$0	$186,762,508	$8,781,205	$239,865,561	$0	$0	$18,546,250
2019	$0	$0	$0	$0	$236,747,130	$8,781,205	$245,528,335	$0	$0	$22,950,820
2020	$194,731,769	$0	$0	$0	$1,037,258	$8,781,205	$204,550,232	$0	$0	$27,364,833
2021	$340,148,097	$101,885,129	$0	$0	$0	$8,781,205	$348,929,302	$101,885,129	$0	$41,358,634
2022	$197,573,148	$0	$1,771,749	$276,777	$21,053,534	$8,781,205	$229,179,636	$276,777	$0	$46,233,184
2023	$768,729	$0	$0	$0	$0	$8,781,205	$9,549,934	$0	$0	$46,250,533
2024	$0	$1,899,362	$0	$0	$0	$8,781,205	$8,781,205	$1,899,362	$0	$46,368,302
2025	$0	$0	$0	$0	$0	$2,897,798	$2,897,798	$0	$0	$46,368,302
2026	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2027	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2028	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2029	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2031	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2032	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2033	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
2034	$0	$0	$0	$0	$0	$0	$0	$0	$0	$46,368,302
NPV 7%	$836,547,207	$116,749,585	$51,304,086	$8,384,297	$324,222,172	$56,897,181	$1,268,970,646	$125,133,882	$18,219,058	$331,030,067
NPV 3%	$1,015,437,919	$142,927,493	$59,231,114	$9,437,431	$387,644,765	$70,604,808	$1,532,918,606	$152,364,924	$19,661,608	$510,631,020

The total costs of the Option 3 tank car standard over 20 years are $1.743 billion at a 7 percent discount rate and $2.216 billion discounted at 3 percent.

Costs of the AAR 2014 Standard (Option 2)

PHMSA also considered another standard that mandates all cars to meet or exceed the performance achieved by an Option 2 - AAR 2014 tank car. The costs for mandating this standard are developed in this section.

The cost analysis is similar to that for the Final Rule car, with the following change:

The retrofit costs for the DOT-111 unjacketed, DOT-111 Jacketed, and CPC-1232 unjacketed would be higher, because the Option 2 requires extra shell thickness, full height head shields, a

thermal blanket, and full jacket. In addition, the CPC-1232 with a jacket would have to have a thicker jacket applied to meet the puncture resistance standards of this car standard, which means removal of the old jacket and replacement with a new thicker jacket.

Table TC23: Retrofit Costs for the Non-Jacketed DOT-111 to AAR 2014 Tank Car	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full-jacket retrofit cost (assumed to include full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$0
Wheel bearings	12000
Unadjusted Total	**$45,100**
Learning curve cost reduction	10%
Adjusted Total	**$40,590**

Table TC24: Retrofit Costs for the Jacketed DOT-111 to AAR 2014 Tank Car	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to include full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$0
Wheel bearings	$0
Unadjusted Total	**$33,100**
Learning curve cost reduction	10%
Adjusted Total	**$29,790**

Table TC25: Retrofit Costs for the Non-Jacketed CPC-1232 to AAR 2014 Tank Car	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to include full-height head shield cost)	$23,400
Increased 1/16-inch thickness (assumed to be added to jacket)	$1,500
ECP brakes retrofit cost	$0
Wheel bearings	0
Unadjusted Total	**$31,600**
Learning curve cost reduction	10%
Adjusted Total	**$28,440**

Table TC26: Retrofit Costs for the Jacketed CPC-1232 to AAR 2014 Tank Car	
Retrofit Option	**Cost**
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to included full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$0
Wheel bearings	$0
Unadjusted Total	**$33,100**
Learning curve cost reduction	10%
Adjusted Total	**$29,790**

We continued all other assumptions listed in the cost analysis for the final rule designed car.

Table TC27: Increased Fuel and Maintenance Costs, AAR Tank Car					
Tank Car	**Increased weight to achieve PHMSA and FRA designed car standard (tons)**	**Miles Per Year, Per Car**	**Additional Fuel Costs per Ton-Mile**	**Additional Maintenance Cost per Ton-Mile**	**Annual Additional Fuel and Maintenance Costs**
Retrofitted Non-Jacketed DOT-111	10.25	15,400	$0.0063	$0.00083	$1,125
Retrofitted Jacketed DOT-111	4.75	15,400	$0.0063	$0.00083	$522
Retrofitted Non-Jacketed CPC-1232	7	15,400	$0.0063	$0.00083	$769
Enhanced Jacketed CPC-1232	2.25	15,400	$0.0063	$0.00083	$247
Replacement of jacketed CPC-1232 with a New AAR Tank Car	2.25	15,400	$0.0063	$0.00083	$247
Replacement of retired unjacketed DOT-111 with a New AAR Tank Car	10.25	15,400	$0.0063	$0.00083	$1,125
Replacement of retired jacketed DOT-111 with a New AAR Tank Car	4.75	15,400	$0.0063	$0.00083	$522

Table TC28: Summary of Cost Estimates for AAR Tank Car		
Variable	**Formula/Input**	**Source**
Number of DOT-111 Non-Jacketed Retrofitted 2016-2018	30,475 tank cars	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Non-Jacketed	$40,590	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM

Table TC28: Summary of Cost Estimates for AAR Tank Car		
Variable	**Formula/Input**	**Source**
Time Out-of-Service Cost of DOT-111 Non-Jacketed	$1,033	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to AAR 2014 car (based on 11.5 tons of extra weight)	$1,125	DOT Adaptation of EIA and CSX Corporation Data
Number of DOT-111 Jacketed Retrofitted 2016-2018	2,356	
Unit Cost Per Retrofit of DOT-111Jacketed	$29,970	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of DOT-111 Non-Jacketed	$1,033	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to AAR 2014 car	$522	N/A
Number of CPC-1232NJ 2021-2025	15,895 tank cars	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Non-Jacketed	$28,440	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of CPC-1232 Non-Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to AAR 2014 car (based on 7.07 tons of extra weight)	$769	DOT Adaptation of EIA and CSX Corporation Data
Number of CPC-1232 Jacketed Retrofitted 2016-2018	24,933	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Jacketed	$29,790	N/A
Time Out-of-Service Cost of CPC-1232 Jacketed		N/A
Additional Fuel and Maintenance Costs Per Year, Relative to AAR 2014 car	$247	N/A
Number of New AAR 2014 Constructed, 2015-2019	6,953 tank cars	DOT Estimate
Incremental Cost of AAR 2014 Cars, Relative to AAR 2014 car	$3,000	DOT Estimate
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Additional Fuel and Maintenance Costs Per Year, Relative to AAR 2014 car (based on 2.57 tons of extra weight)	$247	DOT Adaptation of EIA and CSX Corporation Data
Tank Car Capacity Loss from Enhanced Tank Car Standards	None	DOT Estimate
Number of DOT-111NJ Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	11,851	DOT Estimate
Cost of retirement	$14,167	DOT Estimate

Table TC28: Summary of Cost Estimates for AAR Tank Car		
Variable	**Formula/Input**	**Source**
Number of DOT-111J Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	916	DOT Estimate
Cost of retirement	$11,297	DOT Estimate
Percentage of Track Capable of Handling 286,000 pounds of Gross Rail Load (GRL)	100%	DOT Estimate
Percentage of DOT-111 Non-Jacketed and CPC-1232 Non-Jacketed in PG II and PG III service	100%	DOT Estimate

The 20 year undiscounted and discounted costs for this option are presented in the tables below.

Table TC29: Costs of Option 2 Tank Car

	DOT 111 Unjacketed		DOT 111 Jacketed		CPC 1232 Unjacketed	CPC 1232 Jacketed	**Total**		**Planned New Construction (Additional Cost)**	**Fuel and track Maintenance**
Year	Retrofits	Retirements*	Retrofits	Retirements*	Retrofits	Retrofits	**Retrofits**	**Retirements***	**New Construction**	**Fuel and track Maintenance**
2015	$0	$0	$0	$0	$0	$19,997,151	$19,997,151	$0	$0	$160,747
2016	$183,682,299	$0	$0	$0	$0	$79,988,604	$263,670,903	$0	$20,859,000	$7,488,204
2017	$300,684,552	$64,112,759	$22,100,091	$10,073,786	$0	$79,988,604	$402,773,247	$74,186,544	$0	$22,193,951
2018	$0	$0	$48,577,048	$0	$195,756,208	$79,988,604	$324,321,860	$0	$0	$28,779,421
2019	$0	$0	$0	$0	$248,147,880	$79,988,604	$328,136,484	$0	$0	$35,913,353
2020	$208,239,869	$0	$0	$0	$1,087,208	$79,988,604	$289,315,681	$0	$0	$42,215,507
2021	$363,743,397	$101,885,129	$0	$0	$0	$79,988,604	$443,732,001	$101,885,129	$0	$60,788,051
2022	$211,278,348	$0	$1,941,849	$276,777	$22,067,384	$79,988,604	$315,276,185	$276,777	$0	$67,766,792
2023	$822,054	$0	$0	$0	$0	$79,988,604	$80,810,658	$0	$0	$68,432,006
2024	$0	$1,899,362	$0	$0	$0	$79,988,604	$79,988,604	$1,899,362	$0	$69,225,884
2025	$0	$0	$0	$0	$0	$26,396,239	$26,396,239	$0	$0	$69,438,069
2026	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2027	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2028	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2029	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2031	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2032	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2033	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
2034	$0	$0	$0	$0	$0	$0	$0	$0	$0	$69,438,069
NPV 7%	$894,576,584	$116,749,585	$56,229,628	$8,384,297	$339,835,354	$518,280,364	$1,808,921,931	$125,133,882	$18,219,058	$498,132,967
NPV 3%	$1,085,876,539	$142,927,493	$64,917,705	$9,437,431	$406,312,113	$643,144,089	$2,200,250,446	$152,364,924	$19,661,608	$767,051,450

The total costs of the Option 2 tank car standard over 20 years are $2.45 billion at a 7 percent discount rate and $3.139 billion discounted at 3 percent.

PHMSA also considers another standard that mandates all cars to meet or exceed the performance achieved by Option 1 – PHMSA FRA design tank car (described above). The costs for mandating this standard are developed in this section.

The cost analysis is similar to that for the Option 2 car, with the following changes:

1) The incremental cost for newly constructed car—relative to the baseline Option 3 tank car—would be higher, because the Option 1 car requires ECP brakes and roll-over protection for newly constructed cars. PHMSA estimates the cost of ECP brakes on a new car at $7,800, and rollover protection to cost $5,000 for an Option 1 car. The thicker

shell plus the rollover protection cost and the ECP brake cost raises the new car cost differential for this option to $14,800.

2) The retrofit costs for all tank cars currently in the fleet would be higher, because the Option 1 car requires ECP brakes, a thicker shell, full height head shields, a thermal blanket, and full jacket. Retrofitting rollover protection on older car designs is not feasible, so PHMSA did not propose requiring rollover protection for this car standard.

Table TC30: Retrofit Costs for the Non-Jacketed DOT-111, Jacketed DOT-111, and Jacketed CPC-1232 to PHMSA-FRA Designed Car

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full-jacket retrofit cost (assumed to included full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$7,800
Truck upgrade	$12,000
Unadjusted Total	**$52,600**
Learning curve cost reduction	10%
Adjusted Total	**$47,340**

Table TC31: Retrofit Costs for the Jacketed DOT-111

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to included full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$7,500
Unadjusted Total	**$40,600**
Learning curve cost reduction	10%
Adjusted Total	**$36,540**

The retrofit costs for the CPC-1232NJ are slightly lower than the other car configurations, because this car has an 8/16ths inch thick tank. Thus, only 1/16th thickness needs to be added to the thickness of the enhanced jacket, rather than a full eighth inch as with the other cars. As a result, the costs of adding shell thickness to this car are half what they would be for the other car configurations.

Table TC32: Retrofit Costs for the Non-Jacketed CPC-1232 to PHMSA-FRA Designed Car

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500

Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to included full-height head shield cost)	$23,400
Increased 1/16-inch thickness (assumed to be added to jacket)	$1,500
ECP brakes retrofit cost	$7,800
Truck upgrade	0
Unadjusted Total	**$39,400**
Learning curve cost reduction	10%
Adjusted Total	**$35,460**

Table TC33: Retrofit Costs for the Jacketed CPC-1232 to PHMSA-FRA Designed Car

Retrofit Option	Cost
Bottom outlet valve handle retrofit cost	$1,200
Pressure relief valve retrofit cost	$1,500
Thermal protection retrofit cost	$4,000
Full jacket retrofit cost (assumed to included full-height head shield cost)	$23,400
Increased 1/8-inch thickness (assumed to be added to jacket)	$3,000
ECP brakes retrofit cost	$7,500
Unadjusted Total	$40,600
Learning curve cost reduction	10%
Adjusted Total	$36,540

Table TC34: Extra Fuel and Track Maintenance Costs Associated with the Heavier Cars

Tank Car	Weight Increase in Tons	Miles Per Year, Per Car	Additional Fuel Costs per Ton-Mile	Additional Maintenance Cost per Ton-Mile	Additional Annual Fuel and Maintenance Costs
Retrofitted Non-Jacketed DOT-111	10.75	15,400	$0.0063	$0.00083	$1,180
Retrofitted Jacketed DOT-111	5.25	15,400	$0.0063	$0.00083	$576
Retrofitted Non-Jacketed CPC-1232	7.5	15,400	$0.0063	$0.00083	$824
Enhanced Jacketed CPC-1232	2.75	15,400	$0.0063	$0.00083	$302
Replacement of Jacketed CPC-1232 with Option 1 New construction	2.75	15,400	$0.0063	$0.00083	$302
Replacement of Retired Non-Jacketed DOT-111 with an Option 1 New Car	10.75	15,400	$0.0063	$0.00083	$1,180
Replacement of retired jacketed DOT-111 with an Option 1 New Car	5.25	15,400	$0.0063	$0.00083	$576

As noted in the NPRM, the Agency was unable to model the safety improvement attributable to rollover protection for this car. In addition, because this car option requires all cars in HHFT

service to be retrofit or built with ECP brake technology, regardless of whether they are operated in true unit train service or are being shipped in relatively large volumes in manifest trains. Shipping in manifest trains along with cars that are not ECP equipped prevents the deployment of ECP technology. The costs of equipping cars with ECP technology are therefore incurred but without the accompanying benefit, for some portion of the fleet. This is obviously wasteful, and was a reason for the decision by the Agency to require only cars operating in true unit train service to be equipped with ECP technology.

As presented above, the Option 1 car is marginally more expensive than the Option 2 car but would produce the same safety benefits as that car. Higher costs accompanied by equivalent benefits obviously makes the Option 1 car inferior to the Option 2 car from a cost benefit standpoint. The Option 1 car is also not demonstrably safer. As a result, the Agency drops consideration of this car from the rest of the analysis.

Table TC35: Tank Car Option 1, FRA and PHMSA Designed Car

Variable	Formula/Input	Source
Number of DOT-111NJ Retrofitted 2016-2020	30,130 tank cars	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Non-Jacketed	$47,340	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of DOT-111 Non-Jacketed	$1,033	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to FRA and PHMSA Designed Car(based on 11.93 tons of additional weight)	$1,180	DOT Adaptation of EIA and CSX Corporation Data
Number of DOT-111 Jacketed Retrofitted 2016-2018	2,356	DOT Estimate
Unit Cost Per Retrofit of DOT-111 Jacketed	$36,540	N/A
Time Out-of-Service Cost of DOT-111 Jacketed	$1033	N/A
Additional Fuel and Maintenance Costs Per Year, Relative to FRA and PHMSA Designed Car	$576	N/A
Number of CPC-1232 Non-Jacketed Retrofitted 2016-2018	15,895 Tank Cars	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Non-Jacketed	$35,640	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Time Out-of-Service Cost of CPC-1232 Non-Jacketed	$944	DOT Adaptation of Watco Companies, L.L.C. Public Comment on the 2013 APRM
Additional Fuel and Maintenance Costs Per Year, Relative to FRA and PHMSA Designed Car (based on 7.5 tons of extra weight)	$824	DOT Adaptation of EIA and CSX Corporation Data
Number of CPC-1232 Jacketed Retrofitted 2016-2018	24,933	DOT Estimate
Unit Cost Per Retrofit of CPC-1232 Jacketed	$36,540	N/A
Time Out-of-Service Cost of CPC-1232 Jacketed	0	N/A

Table TC35: Tank Car Option 1, FRA and PHMSA Designed Car		
Variable	**Formula/Input**	**Source**
Additional Fuel and Maintenance Costs Per Year, Relative to FRA and PHMSA Designed Car	$302	N/A
Number of New PHMSA and FRA Designed Cars Constructed, 2015-2019	6,953 Tank Cars	DOT Estimate
Incremental Cost of New PHMSA and FRA Designed Cars, Relative to Enhanced Jacketed CPC-1232	$14,800	DOT Estimate
Other Costs from Factory Re-Tooling or Capacity Issues	Not Estimated	N/A
Additional Fuel and Maintenance Costs Per Year, Relative to FRA and PHMSA Designed Car (based on 3 tons of extra weight)	$302	DOT Adaptation of EIA and CSX Corporation Data
Tank Car Capacity Loss from Enhanced Tank Car Standards	None	DOT Estimate
Number of DOT-111 NJ Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	11,851	DOT Estimate
Cost of retirements	$14,167	DOT Estimate
Number of DOT-111 J Tank Car Early Retirements (as a result of the cost of retrofits), 2015-2034	916	DOT Estimate
Cost of Retirement	$11,297	DOT Estimate
Percentage of Track Capable of Handling 286,000 pounds of Gross Rail Load (GRL)	100%	DOT Estimate
Percentage of DOT-111 Non-Jacketed and CPC-1232 Non-Jacketed in PG II and PG III service	100%	DOT Estimate

C. Tank Car Benefits

This section analyzes the benefits for the three tank car Options considered at the NPRM stage as well as the Final Rule Option promulgated by the final rule that this document accompanies. We assess benefits by considering the expected effectiveness of the enhancements in reducing the expected damages of crude oil and ethanol accidents. All of the Options are designed to address the survivability of the tank car and would mitigate the damages of rail accidents better than the current DOT-111. Specifically, the tank car Options incorporate several enhancements to increase puncture resistance; provide thermal protection to survive a 100-minute pool fire; and protect top fitting and bottom outlets during a derailment. Under all Options, the proposed system of design enhancements would reduce the consequences of a derailment of tank cars carrying crude oil or ethanol. There would be fewer car punctures, fewer releases from the service equipment (top and bottom fittings), and delayed release of flammable liquid from the tank cars through the pressure relief devices.

We explain the benefits calculation for the Final Rule Option first, as the benefits to the other Options were calculated in a similar way. We begin by presenting the expected lower

consequence event damages over 20 years. The explanation of how these damages were derived is in the societal damages section. These are the damages for events that are more typical of the average crude and ethanol incident, with lower quantities released, lower environmental damages because no particularly valuable or difficult to remediate environmental asset has been affected, and a low number of injuries and fatalities. Table TC36 below presents the figures arrived at in the societal damages section of this document.

Table TC36: Tank Car Damages with Societal Factors

Year	Total Damages
2015	$179,915,412
2016	$176,427,442
2017	$182,777,809
2018	$196,334,749
2019	$208,471,811
2020	$221,509,522
2021	$222,699,151
2022	$223,063,891
2023	$208,678,220
2024	$223,774,639
2025	$223,247,669
2026	$219,084,383
2027	$201,212,338
2028	$212,100,606
2029	$208,330,088
2030	$204,293,980
2031	$200,686,778
2032	$196,924,311
2033	$193,606,475
2034	$190,456,652
Total	$4,093,595,927

1. Using Marginal Effectiveness Rates

PHMSA mandates that all DOT jacketed, non-jacketed legacy DOT-111 cars, and non-jacketed CPC-1232 cars be retrofit to meet the NPRM Option 3 standard by being equipped with a jacket and full height head shields (where needed), thermal protection, a better PRV and an enhanced BOV handle. These enhancements significantly improve the survivability of legacy car designs in the event of an incident such as a collision or derailment. We calculate benefits by adjusting the likelihood of release of the existing car design in question relative to the release rate of that same car with the enhancements just listed. Thus, the benefits of retrofitting existing cars are the effectiveness differential/expected release rate between existing cars and the DOT-117.

For the final rule, new construction – those cars that are built to satisfy growing demand going forward – the benefits are calculated using the effectiveness differential between an Option 3 tank car and the Option 2 tank car. For cars that are retired rather than retrofit, the effectiveness differential is the difference between the car configuration being retired (e.g. a DOT-111NJ) and the new car design (the Option 2 tank car).

2. Determining Effectiveness Rates

Table TC37: Effectiveness of Existing Tank Car Options Relative to the Non-Jacketed DOT-111

Tank Car	Total	Head puncture	Shell puncture	Thermal damage	Top fittings	BOV
Option 1	51	21	17	12	N/A	<1
Option 2	50	21	17	12	N/A	<1
Option 3	40	19	9	12	N/A	0

Table TC37 summarizes the effectiveness of the proposed elements of each option. The effectiveness was calculated using the following assumptions:

1) PHMSA examined the 16 accidents provided in Appendix B.
2) DOT-111 tank cars composed the vast majority of the type of tank cars involved in the derailments listed in Appendix B. The type of damages these tank cars experienced were used to design the tank car options in the final rule.
3) The volume of lading lost from each tank car in the derailments indicated in Appendix B compiled relative to the documented damage to each tank car that lost lading. These values were used as the baseline for tank cars constructed to the current DOT-111.
4) Improvement in performance was based on the following assumptions.
    a. The ratio of puncture force (DOT-111/option) was used as a multiplier to determine the reduction in lading loss.
    b. Thermal protection prevented thermal damage that results in loss of containment.
    c. Top fittings protection halves the damage to service equipment.
    d. BOV modification prevents lading loss through valve.
5) The reduced volume of lost lading relative to each enhancement was compared to the baseline to calculate the respective reduction or effectiveness.

E.I. DuPont de Nemours and Company developed the analytical method to determine the ratio of puncture force. Transportation Technology Center in Pueblo, CO validated this ratio by performing full-scale testing. FRA calculated the shell puncture resistance of all three Options, which also provide the necessary effectiveness for the Final Rule Option, compared to the other

tank car configurations.[134] These results are available for review in the public docket for this rulemaking.

The rollover protection for the Option 1 tank car is based on the load conditions described in 179.102-3. The top fittings protection for the Option 2 and Option 3 tank cars must meet the load conditions in M-1002 Appendix E, 10.2.1. The former is a dynamic load and the latter is a static load. Rollover protection should provide some safety benefit compared to static load top fittings, but the modelling conducted to estimate effectiveness rates is unable to estimate the extent of the decrease in likelihood of release for rollover protection. As a result, we assume no marginal safety benefit for that feature.

The proposed materials, minimum thickness of 9/16 inch, and jacket provide a 44.9 percent improvement in the puncture force for Options 1 and 2 relative to the current specification requirements for a non-jacketed DOT-111 tank car. A tank car constructed to the proposed requirements of Option 3 would have a 35 percent improvement in puncture force relative to the current unjacketed DOT-111 tank car.[135]

The combination of the shell thickness and head shield of Options 1 and 2 provide a head puncture resistance velocity of 18.4 mph (21% effectiveness rate). Because the Option 3 tank car has a 7/16 inch shell, as opposed to the 9/16 inch shell in Options 1 and 2, it has a head puncture resistance velocity of 17.8 mph.

For a detailed description of how tank car enhancements effectiveness rates were developed, the reader is referred to that section of the document. We reproduce the rates used to calculate benefits in the Tables below.

Table TC38: Shell and Head Puncture Velocities by Tank Car Option

Tank Car	Shell Puncture Velocity*	Head Puncture Velocity*
Option 1	12.3 mph (66%)	18.4 mph (114%)
Option 2	12.3 mph (66%)	18.4 mph (114%)
Option 3	9.6 mph (30%)	17.8 mph (107%)
CPC-1232 Non-Jacketed	8.5 mph (15%)	Top – 10.3 (20%) Bottom – 17.6 (105%)

[134] "Detailed Puncture Analyses Tank Cars: Analysis of Different Impactor Threats and Impact Conditions" can be found at: http://www.fra.dot.gov/eLib/details/L04420

[135] Modeling and simulation of puncture velocity indicate a puncture velocity of approximately 7.4 mph for a legacy DOT Specification 111; 9.6 mph for Option 3; and 12.3 mph for the cars under Options 1 and 2. Puncture velocity is based on an impact with a rigid 12" x 12" indenter with a weight of 297,000 pounds.

Table TC38: Shell and Head Puncture Velocities by Tank Car Option		
DOT-111 Jacketed	9.3 mph (26%)	11.6 mph (35%)
*improvement relative to DOT-111 non-jacketed		

The proposed changes for existing tank cars are based on commenter input, simulations, and modeling. Modeling and simulation of puncture velocity of DOT-111 tank cars currently used to transport ethanol or crude oil indicate that a velocity of approximately 7.4 mph will puncture the shell of the tanks when struck with a rigid 12" x 12" indenter with a weight of 297,000 pounds. Validation of this model has been accomplished using the results of puncture tests performed at the Transportation Technology Center in Pueblo, CO.[136] Further, based on modeling and simulation, the head of an unjacketed DOT-111 tank car, when struck with a 12" x 12" indenter weighing 286,000 pounds, will puncture at 7.6 mph. Table TC38 provides the tank car shell and head puncture velocities of the DOT-117 tank car Options proposed in the NPRM.

Similar to the methodology for estimating the effectiveness of new cars, PHMSA uses these puncture velocities to arrive at risk reduction estimates for retrofits.

In evaluating train accidents involving HHFTs, we examined derailments that occurred at a variety of speeds. Some of the documented derailment speeds exceed the puncture velocity of both the DOT-111 tank car and the options proposed in this rule. However, during a derailment, the speeds of impacts will vary considerably between cars, and many of those impacts will not result in a puncture. The portion of those impacts that could result in a puncture would decline with the higher puncture velocity of the DOT-117 tank car options proposed in this NPRM. Because of use of the proposed DOT-117 tank cars, we would expect the volume of flammable liquid released into the environment, and the overall consequences of a train accident, to be reduced.

Cars can be upgraded by either being retrofit, in which case the marginal safety improvement is from the car type being altered to a jacketed CPC-1232, or retired and replaced, in which case the safety improvement is the difference between the type of car being retired and the Option 2 tank car. In addition, new cars that are built to expand the size of the fleet are evaluated at the difference between the Option 2 car and the CPC-1232J. As a result, a combination of effectiveness rates for the Option 2 and 3 cars are needed to compute the estimated benefits of the final rule. These effectiveness rates are presented in the two tables below. We also present the Option 1 tank car effectiveness without ECP – this car is equivalent to the Option 2 car so they can both be presented in the same table.

[136] "Detailed Puncture Analyses Tank Cars: Analysis of Different Impactor Threats and Impact Conditions" can be found at: http://www.fra.dot.gov/eLib/details/L04420

Table TC39: Relative Effectiveness of the Options 1 and 2 Tank Car		
AAR 2014 Car		
Variable	**Formula/Input**	**Source**
Risk Reduction, DOT-111 Non-Jacketed to AAR 2014 Car	50.4%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Non-Jacketed to AAR 2014 Car	36.8%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, DOT-111 Jacketed to AAR 2014 Car	42.8%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Jacketed to AAR 2014 Car	16.2%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements

Table TC40: Relative Effectiveness of the Option 3, Enhanced Jacketed CPC-1232 Tank Car		
Variable	**Formula/Input**	**Source**
Risk Reduction, DOT-111 Non-Jacketed to Enhanced Jacketed CPC-1232 Car	45.9%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Unjacketed to Enhanced Jacketed CPC-1232 Car	31.0%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, DOT-111 Jacketed to Enhanced Jacketed CPC-1232 Car	37.6%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Jacketed to Enhanced Jacketed CPC-1232 Car	1.0%	/Estimate from FRA subject matter expert

PHMSA did not impose additional top fittings protection requirements on retrofits of existing DOT-111 Non-Jacketed cars, or on the new car standard. In other words, all effectiveness rates presented do not include any benefits from additional top fittings protection, because those benefits are relatively small and uncertain and would apply only to new construction.

HCE Effectiveness Rates

The Agency applies the same effectiveness/mitigation rates to projected HCE damages as to LCE damages. The Agency consulted available information and research on tank car integrity, the interaction of trains with human-built structures such as buildings, and subject matter experts to determine whether it was appropriate to use the same mitigation/prevention factors for HCEs, which are more likely to involve collisions with human-built structures, as to LCEs, which are less likely to involve direct contact with human built structures. The following section summarizes the research findings and reasoning for using the same mitigation factor for both types of incidents.

Research on Tank Car Integrity

In recent years there has been a great deal of research into railroad tank car integrity and developing analytical techniques to determine the effects of safety improvements. Three railroad accidents that resulted in fatalities from the release of hazardous material Minot, ND on January 18, 2002, Macdona, TX, on June 28, 2004 and Graniteville, SC on January 6, 2005 focused attention on improving the structural integrity of tank cars. Based on the circumstances surrounding those events car-to-car impacts were of greatest concern. Specifically head impacts where railroad equipment impacts the tank head and shell impact where the tank is impacted on its side. Results from dynamic, nonlinear finite element analysis are compared to data obtained from full-scale tests to validate the analysis. The intent of this research is to examine the structural integrity of railroad tank cars under a range of conditions varying from normal operating conditions to rare and extreme circumstances such as accidents. The results of that research would provide a technical basis for ongoing tank car rail safety initiatives. While much of that research has been focused on improving the safety of rail tank cars transporting materials toxic by inhalation, many of the safety features examined in this work (head shields and increased shell thickness) are applied to improving DOT-111 tank cars.

Further Information including the full text of these articles may be obtained through the following URLs:

- **Improved Tank Car Safety Research:** https://www.fra.dot.gov/eLib/Details/L02880
- **Next Generation Tank Car Project**: https://www.fra.dot.gov/Page/P0605
- **Engineering Analysis for Railroad Tank Car Head Puncture Resistance:** https://www.fra.dot.gov/eLib/Details/L02877
- **Analyses of Full-Scale Tank Car Shell Impact Tests:** https://www.fra.dot.gov/eLib/Details/L02879

Impact Resistance of Structures

Research into impact resistance of structures has focused on the impacts of windblown debris on buildings. With respect to residential and light commercial structures, missile impact resistance is usually quantified based on the ability of a wall system to withstand the impact of a 2 × 4 in. (50 × 100 mm) wood stud. The testing focused primarily on hurricane-generated missiles. This research is not pertinent to this investigation because the forces to which tank cars are subjected in a derailment are much greater than the impact resistance of any normal structure.

Development of Crash Wall Design Loads from Theoretical Train Impact (2014) considered the impacts of a derailed train to determine ta reasonable impact load for the design of a crash wall. Two impact modes were considered, a glancing blow from a derailed train in the direction of the track and a direct impact as a result of cars piling up in an accordion fashion. The paper compared energy load cases for a freight train with a speed of 50 mph and passenger train speed of 70 mph.

Potential Combustion Hazards Associated with Rail Accidents of Flammable Liquids

The behavior of a flammable liquid and the hazards it poses upon release depends upon the type of release and environmental factors. The proximity of an ignition source is unrelated to population. This is evidenced in the numerous accidents in unpopulated areas where fires have occurred. Common types of hazards posed by flammable liquids involved in rail tank car accidents include: BLEVE, pool fire, fire ball, flash fire, and radiant heat impacts. These combustion hazards are described more thoroughly in the Sandia report but indicate that fragments generated from a BLEVE have the potential to provide the largest hazard footprint in the immediately after an accident. The severity of other thermal hazards e.g. pool fires and flash fires can vary depending on wind speed and direction and the proximity of surrounding infrastructure.

Application of Effectiveness Rates to HCEs

The Sharma model did not to test whether the rule's tank car standards and ECP requirements effectiveness rates would be the same or different in an HCE compared to an LCE, and PHMSA was unable to identify existing studies on this issue. However, PHMSA believes it is reasonable to assume the tank car standards and ECP requirements would have the same effectiveness at mitigating damages in HCEs as for LCEs.

A high consequence event can be expected to entail derailed cars colliding with significant places of congregation, buildings or infrastructure. The Agency believes the forces in play when a derailed car impacts a building are similar to the forces in play when tank cars collide with one another in an LCE derailment that does not involve interaction with other human-made structures. An HCE is likely to resemble a somewhat severe LCE with regard to most of the dynamic forces impacting the tank cars – it is the exacerbating factors of the presence of significant numbers of people, infrastructure or other valuable resources that are damaged by an event that distinguishes an HCE from an LCE. Tank car collisions are explicitly accounted for in the Sharma model used to determine effectiveness rates of the rule's provisions. As a result, the enhancements adopted by the final rule are likely to have the same relative effectiveness whether or not a derailment involves a collision with a building.

PHMSA believes that mitigating the quantity released could be expected to reduce the consequences of HCEs at the same rate as in LCEs. The distinguishing feature of an HCE is the proximity of a high concentration of people, valuable infrastructure, or an area of particular environmental sensitivity that would be impacted by the derailment. Given the presence of such aggravating factors, a smaller quantity release of flammable liquid in the event of a HCE would

mean a smaller area impacted by the consequent fire, which in turn may mean less property damage and a reduction in total fatalities, as more paths of egress would be available to those fleeing the event.

A larger quantity released may block avenues to escape the event that would continue to be available if the quantity released is reduced, thereby increasing the number of fatalities. In addition, the non-fatality damages associated with an HCE are likely to be mitigated by a smaller fire/quantity released. While even a single-car release could result in catastrophic loss of life if it occurs in the wrong place at the wrong time, mitigating the quantity released has the potential to mitigate the damages and lives lost during an HCE event, just as for an LCE event. Furthermore, whether a car will release is determined by the individual dynamics of each derailment. It is likely that in some cases, the tank car enhancements may reduce the quantity released by only a small amount, while, due to different dynamics the same enhancements may completely prevent any release in another derailment. On average, the Agency believes that the reductions in the relative probability of release estimated by its modelling would apply to HCE as well as LCE events.

Calculating Tank Benefits

The tank car benefits are calculated by multiplying the percentage of the fleet upgraded via retrofit in a given year from one of the three inferior designs by the marginal effectiveness of the Option 3 tank car relative to each of these cars. This value is then multiplied by the societal damages to get the estimated reduction in societal damages – i.e., benefits. Retirements are treated analogously; the percentage of the fleet that it gets upgraded via retirement is multiplied by the marginal effectiveness between the car retired and the Option 2 car. Finally, fleet expansion benefits are calculated based on the percentage of the fleet accounted for by new cars in each year multiplied by the marginal effectiveness of the Option 2 tank car relative to the Option 1 tank car, multiplied by societal damages. It should be noted that the percentage of upgraded cars is cumulative. For example, if 10,000 cars of the DOT-111NJ type were upgraded in year 1 to a CPC-1232J standard, and that amount comprised 20 percent of the fleet, the weighted benefit effectiveness calculation for those cars would yield 0.2 x 0.35 = 0.07. If an equal number of DOT-111s underwent this same upgrade in Year 2, and the fleet did not expand so the percentage of the total fleet remains constant, the percentage of upgraded cars would double, and the cumulative upgrade percent in Year 2 would be 0.4. The weighted effectiveness for these upgrades would then be 0.4 x 0.35 = 0.14. A comprehensive discussion of effectiveness rates is provided in Sharma's full report, entitled *Objective Evaluation of Risk Reduction from Tank Car Design & Operations Improvements – Extended Study*. The report is available in the public docket for this proceeding (PHMSA-2012-0082). The table below presents the expected fleet composition in each year.

Table TC41: Projected Fleet Composition, 2015-2034

	DOT 111 Unjacketed		DOT 111 Jacketed		CPC 1232 Unjacketed		CPC 1232 Jacketed		Planned New Construction	Unjacketed DOT 111 Un-Planned New Construction	Jacketed DOT 111 Un-Planned New Construction	Total Cars
Base Year Fleet	42,326	11,851	3,272	916	15,895	0	24,933	0				
Year												
2015	0	0	0	0	0	0	651	0	0	0	0	651
2016	4,413	0	0	0	0	0	3,253	0	6,953	0	0	14,619
2017	11,637	4,526	717	892	0	0	5,856	0	6,953	0	0	30,580
2018	11,637	4,526	2,293	892	6,662	0	8,458	0	6,953	0	0	41,421
2019	11,637	4,526	2,293	892	15,107	0	11,061	0	6,953	0	0	52,468
2020	16,640	4,526	2,293	892	15,144	0	13,664	0	6,953	0	0	60,111
2021	25,379	11,717	2,293	892	15,144	0	16,266	0	6,953	0	0	78,644
2022	30,455	11,717	2,356	916	15,895	0	18,869	0	6,953	0	0	87,161
2023	30,475	11,717	2,356	916	15,895	0	21,472	0	6,953	0	0	89,784
2024	30,475	11,851	2,356	916	15,895	0	24,074	0	6,953	0	0	92,520
2025	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2026	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2027	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2028	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2029	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2030	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2031	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2032	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2033	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379
2034	30,475	11,851	2,356	916	15,895	0	24,933	0	6,953	0	0	93,379

The next table presents the cumulative percentages of the fleet that are upgraded via new construction, retirement replacement, or retrofit, made up by each of the tank car types currently in service.

Table TC42: Projected Fleet Composition Percentages, 2015-2034

	DOT-111 Non-Jacketed		DOT-111 Jacketed		CPC-1232 Non-Jacketed	CPC-1232 Jacketed	Planned New Construction	Total Cars
Year	Retrofit	Retire-ment	Retrofit	Retire-ment	Retrofit	Retrofit	New	Total Upgrades
2015	0.00	0.00	0.00	0.00	0.00	0.008	0.00	0.008
2016	0.047	0.00	0.00	0.00	0.00	0.035	0.074	0.157
2017	0.125	0.048	0.01	0.01	0.00	0.063	0.074	0.327
2018	0.125	0.048	0.02	0.01	0.07	0.091	0.074	0.444
2019	0.125	0.048	0.02	0.01	0.16	0.118	0.074	0.562
2020	0.178	0.048	0.025	0.010	0.162	0.146	0.074	0.644
2021	0.272	0.125	0.025	0.010	0.162	0.174	0.074	0.842
2022					0.170	0.202		

Table TC42: Projected Fleet Composition Percentages, 2015-2034								
	0.326	0.125	0.025	0.010			0.074	0.933
2023	0.326	0.125	0.025	0.010	0.170	0.230	0.074	0.961
2024	0.326	0.127	0.025	0.010	0.170	0.258	0.074	0.991
2025	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2026	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2027	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2028	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2029	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2030	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2031	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2032	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2033	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000
2034	0.326	0.127	0.025	0.010	0.170	0.267	0.074	1.000

In order to calculate benefits, we multiply the effectiveness rate for each car relative to the Option 3 or Option 2 car presented above, depending on whether a car is retrofit or retired, by the percentage of cars of that type to get weighted effectiveness rates, which are applied to the damage pool.

For newly constructed cars, we make a similar adjustment. Beginning in mid- to late 2015, we expect all new cars to be built to the new standard promulgated by this rule. New cars get evaluated at the difference between a CPC-1232J and an Option 2 car if built for continued fleet growth, and the difference between the car being replaced and the Option 2 car for cars being retired rather than retrofit. No benefits are claimed for retired cars until the year they are retired, or retrofit cars until the year they are retrofit. Estimated benefits are presented below.

Table TC43: LCE Benefits of the Final Rule Tank Car								
Year	**Retrofit DOT-111 No Jacket**	**Retirement DOT-111 No Jacket**	**Retrofit DOT-111 Jacketed**	**Retirement DOT-111 Jacketed**	**Retrofit CPC 1232 No Jacket**	**Retrofit CPC 1232 Jacketed**	**New Construction**	**Total Lower Consequence Benefits**
2015	$0	$0	$0	$0	$0	$13,545	$0	$13,545
2016	$3,827,034	$0	$0	$0	$0	$61,466	$2,128,153	$6,016,653
2017	$10,455,065	$4,464,472	$527,691	$747,044	$0	$114,621	$2,204,755	$18,513,649
2018	$11,230,535	$4,795,610	$1,812,753	$802,454	$4,342,232	$177,844	$2,368,285	$25,529,713
2019	$11,924,786	$5,092,066	$1,924,814	$852,060	$10,455,308	$246,942	$2,514,688	$33,010,664

2020	$18,117,904	$5,410,521	$2,045,191	$905,348	$11,136,385	$324,123	$2,671,955	$40,611,427
2021	$27,781,475	$14,083,913	$2,056,175	$910,210	$11,196,194	$387,933	$2,686,305	$59,102,205
2022	$33,392,591	$14,106,979	$2,116,128	$936,749	$11,770,666	$450,740	$2,690,705	$65,464,559
2023	$31,259,319	$13,197,203	$1,979,656	$876,337	$11,011,561	$479,832	$2,517,178	$61,321,087
2024	$33,520,714	$14,313,856	$2,122,871	$939,734	$11,808,171	$576,914	$2,699,278	$65,981,538
2025	$33,441,775	$14,280,148	$2,117,872	$937,521	$11,780,364	$596,089	$2,692,922	$65,846,691
2026	$32,818,129	$14,013,841	$2,078,376	$920,038	$11,560,675	$584,973	$2,642,702	$64,618,734
2027	$30,140,954	$12,870,647	$1,908,830	$844,985	$10,617,601	$537,253	$2,427,121	$59,347,390
2028	$31,771,981	$13,567,121	$2,012,123	$890,709	$11,192,154	$566,325	$2,558,460	$62,558,875
2029	$31,207,170	$13,325,938	$1,976,354	$874,875	$10,993,191	$556,258	$2,512,979	$61,446,764
2030	$30,602,574	$13,067,766	$1,938,065	$857,926	$10,780,213	$545,481	$2,464,293	$60,256,318
2031	$30,062,227	$12,837,029	$1,903,844	$842,777	$10,589,868	$535,850	$2,420,781	$59,192,377
2032	$29,498,622	$12,596,361	$1,868,151	$826,977	$10,391,329	$525,803	$2,375,397	$58,082,641
2033	$29,001,621	$12,384,134	$1,836,676	$813,044	$10,216,253	$516,945	$2,335,375	$57,104,048
2034	$28,529,788	$12,182,654	$1,806,795	$799,816	$10,050,043	$508,534	$2,297,381	$56,175,011
							Total	$980,193,889
							NPV 7%	$450,032,434
							NPV 3%	$688,875,430

The benefits for the final rule tank car presented above do not include the benefits of reduced higher consequence event risk. The costs presented do include the cost of retrofitting or equipping new cars with ECP brakes. Those are considered in the braking section of this analysis.

To account for higher consequence event risk, we calculate an overall effectiveness ratio for the Final Rule tank car using total non-catastrophic societal damages and non-catastrophic benefits. We divide the total discounted non-catastrophic benefits in each year by the total discounted expected lower consequence event societal damages for that year to get a total weighted effectiveness ratio for that year. This calculation is a shorthand way to arrive at the same total effectiveness rates for all fleet upgrades rather than directly replicating the calculations described above again. Implicit in the use of these effectiveness rates is the assumption that tank car enhancements would be as effective in mitigating high consequence event damages as they are in mitigating lower consequence event damages (see earlier explanation, HCE Effectiveness Rates). The effectiveness ratio for each year is multiplied by the catastrophic damages for that year to get the higher consequence event benefits. We conduct this calculation for two HCE scenarios presented in the societal damages section, the mean and 95th percentile.

The aggregate effectiveness rate for the final rule presented below, along with the HCE benefits at mean HCE damages and HCE benefits at the 95th percentile.

Table TC44: HCE and Total Benefits of Enhanced CPC-1232 J Standard

Year	Aggregate Effectiveness	HCE Benefits, Mean Damages	HCE Benefits, 95th Percentile Damages
2015	0.007	$10,559	$630,900,000
2016	0.032	$4,782,905	$630,900,000
2017	0.118	$14,205,987	$630,900,000
2018	0.157	$18,236,926	$630,900,000

Table TC44: HCE and Total Benefits of Enhanced CPC-1232 J Standard			
2019	0.196	$22,208,018	$630,900,000
2020	0.223	$25,713,354	$630,900,000
2021	0.244	$37,220,996	$630,900,000
2022	0.264	$41,160,424	$630,900,000
2023	0.276	$41,213,129	$630,900,000
2024	0.277	$41,353,706	$630,900,000
2025	0.277	$41,366,606	$630,900,000
2026	0.277	$41,366,606	$630,900,000
2027	0.277	$41,366,606	$630,900,000
2028	0.277	$41,366,606	$630,900,000
2029	0.277	$41,366,606	$630,900,000
2030	0.277	$41,366,606	$630,900,000
2031	0.277	$41,366,606	$630,900,000
2032	0.277	$41,366,606	$630,900,000
2033	0.277	$41,366,606	$630,900,000
2034	0.277	$41,366,606	$630,900,000
	Total	$659,772,064	$2,967,915,831
	7% Discount Rate	$300,935,655.00	$1,353,727,663.03
	3% Discount Rate	$462,092,789.89	$2,078,676,229.19

The net benefits for the final rule tank car standard are presented below.

Table TC45: Final Rule Tank Car Standards Benefits Estimates		
	7% Discount	**3% Discount**
LCE Benefits	$450,032,434	$688,875,430
HCE Benefits, Mean	$300,935,655	$462,092,790
HCE Benefits, 95th Percentile	$1,353,727,663	$2,078,676,229

3. Benefits of the Enhanced Jacketed CPC-1232 (Option 3)

Benefits for the Option 3 tank car are calculated analogously to those for the Option 1 car. However, because ECP braking is not required for this standard, no ECP braking benefits are estimated for this standard. The Option 3 tank car produces lower safety benefits for two reasons. First, it is more likely to release the lading if involved in an accident because it lacks rollover protection, lacks ECP brakes, and has a thinner shell that is less puncture resistant. Secondly, there are no benefits (or costs) associated with construction of an Option 3 tank car to satisfy new demand, because this is the car PHMSA assumes would be built for HHFT service in absence of regulation. The benefits therefore are only attributed to upgrading the safety of the cars that are retrofit. Higher consequence event benefits are also estimated as described above for the Option 1 tank car. The effectiveness rates for upgrading other cars to this standard are presented in the table below.

Table TC46: Relative Effectiveness of the Option 3, Enhanced Jacketed CPC-1232 Tank Car		
Variable	**Formula/Input**	**Source**
Risk Reduction, DOT-111 Unjacketed to Enhanced Jacketed CPC-1232 Car	45.9%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Unjacketed to Enhanced Jacketed CPC-1232 Car	31.0%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, DOT-111 Jacketed to Enhanced Jacketed CPC-1232 Car	37.6%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Jacketed to Enhanced Jacketed CPC-1232 Car	1.0%	N/A

These effectiveness rates are used analogously to the way they were applied above for the Option 1 tank car standard. The fleet composition and all other parameters affecting benefits are assumed to be the same for this standard as for the Option 1 car and thus, those tables are not repeated here. 20 Year benefits are presented below.

Table TC47: LCE Benefits of Enhanced CPC-1232 J Standard

Year	Retrofit DOT-111 No Jacket	Retirement DOT-111 No Jacket	Retrofit DOT-111 Jacketed	Retirement DOT-111 Jacketed	Retrofit CPC 1232 No Jacket	Retrofit CPC 1232 Jacketed	New Construction	Total Lower Consequence Benefits
2015	$0	$0	$0	$0	$0	$13,545	$0	$13,545
2016	$3,827,034	$0	$0	$0	$0	$61,466	$131,367	$4,019,867
2017	$10,455,065	$4,065,859	$527,691	$656,282	$0	$114,621	$136,096	$15,955,614
2018	$11,230,535	$4,367,430	$1,812,753	$704,959	$4,342,232	$177,844	$146,190	$22,781,944
2019	$11,924,786	$4,637,417	$1,924,814	$748,539	$10,455,308	$246,942	$155,228	$30,093,034
2020	$18,117,904	$4,927,438	$2,045,191	$795,352	$11,136,385	$324,123	$164,936	$37,511,330
2021	$27,781,475	$12,826,420	$2,056,175	$799,624	$11,196,194	$387,933	$165,821	$55,213,643
2022	$33,392,591	$12,847,428	$2,116,128	$822,939	$11,770,666	$450,740	$166,093	$61,566,584
2023	$31,259,319	$12,018,881	$1,979,656	$769,866	$11,011,561	$479,832	$155,381	$57,674,498
2024	$33,520,714	$13,035,833	$2,122,871	$825,561	$11,808,171	$576,914	$166,622	$62,056,686
2025	$33,441,775	$13,005,135	$2,117,872	$823,617	$11,780,364	$596,089	$166,230	$61,931,081
2026	$32,818,129	$12,762,606	$2,078,376	$808,257	$11,560,675	$584,973	$163,130	$60,776,145
2027	$30,140,954	$11,721,482	$1,908,830	$742,323	$10,617,601	$537,253	$149,822	$55,818,265
2028	$31,771,981	$12,355,771	$2,012,123	$782,492	$11,192,154	$566,325	$157,930	$58,838,777
2029	$31,207,170	$12,136,122	$1,976,354	$768,582	$10,993,191	$556,258	$155,122	$57,792,799
2030	$30,602,574	$11,901,001	$1,938,065	$753,692	$10,780,213	$545,481	$152,117	$56,673,143
2031	$30,062,227	$11,690,866	$1,903,844	$740,384	$10,589,868	$535,850	$149,431	$55,672,470

2032	$29,498,622	$11,471,686	$1,868,151	$726,503	$10,391,329	$525,803	$146,629	$54,628,725
2033	$29,001,621	$11,278,408	$1,836,676	$714,263	$10,216,253	$516,945	$144,159	$53,708,325
2034	$28,529,788	$11,094,917	$1,806,795	$702,642	$10,050,043	$508,534	$141,814	$52,834,533
							Total	$915,561,007
							NPV 7%	$418,338,960
							NPV 3%	$642,234,605

Table TC48: HCE and Total Benefits of Enhanced CPC-1232 J Standard

Year	Aggregate Effectiveness	HCE Benefits, Mean Damages	HCE Benefits, 95th Percentile Damages
2015	0.007	$10,559	$47,497
2016	0.032	$3,195,571	$14,374,942
2017	0.118	$12,243,143	$55,074,503
2018	0.157	$16,274,081	$73,207,258
2019	0.196	$20,245,173	$91,070,802
2020	0.223	$23,750,510	$106,839,190
2021	0.244	$34,772,083	$156,418,589
2022	0.264	$38,709,598	$174,131,088
2023	0.276	$38,762,303	$174,368,177
2024	0.277	$38,893,819	$174,959,787
2025	0.277	$38,906,718	$175,017,814
2026	0.277	$38,906,718	$175,017,814
2027	0.277	$38,906,718	$175,017,814
2028	0.277	$38,906,718	$175,017,814
2029	0.277	$38,906,718	$175,017,814
2030	0.277	$38,906,718	$175,017,814
2031	0.277	$38,906,718	$175,017,814
2032	0.277	$38,906,718	$175,017,814
2033	0.277	$38,906,718	$175,017,814
2034	0.277	$38,906,718	$175,017,814
Total		$615,924,020	$2,770,669,975
7% Discount Rate		$279,424,202	$1,256,960,635
3% Discount Rate		$430,471,100	$1,936,429,354

Table TC49: CPC-1232 J Standard Benefits Summary

	7% Discount	3% Discount
LCE Benefits	$418,338,960	$915,561,007
HCE Benefits, Mean	$279,424,202	$430,471,100
HCE Benefits, 95th Percentile	$1,256,960,635	$1,936,429,354

Benefits of the AAR 2014 Tank Car (Option 2)

The Option 2 car benefits were calculated analogously to the Final Rule and Option 3 tank cars using the third group of effectiveness ratings. The only differences between the Option 2 car and the Option 1 car are rollover protection and ECP brakes. Accordingly, the effectiveness

differences between this car and the Option 1 tank car are very slight until ECP effects are factored in. The differences in cost between the two cars, excluding ECP brakes, are also minimal. The effectiveness rates of upgrading other tank car designs to this standard are presented in the table below.

Table TC50: Relative Effectiveness of the Option 2, AAR 2014 Tank Car

Variable	Formula/Input	Source
Risk Reduction, DOT-111 Unjacketed to AAR 2014 Car	50.4%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Unjacketed to AAR 2014 Car	36.8%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, DOT-111 Jacketed to AAR 2014 Car	42.8%	Applied Research and Associates, Puncture Resistance Model; DOT Estimate for Top Fittings, Bottom Outlet Valve, Pressure Release Valve, and Thermal Protection Enhancements
Risk Reduction, CPC-1232 Jacketed to AAR 2014 Car	16.2%	N/A

Benefits for this car are calculated analogously to the methodology described for the Final Rule and Option 3 tank cars. Estimated benefits for this tank car standard are presented below.

Table TC51: LCE Benefits of the Option 2 Tank Car, 2015-2034

Year	Retrofit DOT-111 No Jacket	Retirement DOT-111 No Jacket	Retrofit DOT-111 Jacketed	Retirement DOT-111 Jacketed	Retrofit CPC 1232 No Jacket	Retrofit CPC 1232 Jacketed	New Construction	Total Lower Consequence Benefits
2015	$0	$0	$0	$0	$0	$219,425	$0	$219,425
2016	$4,202,233	$0	$0	$0	$0	$995,749	$2,128,153	$7,326,135
2017	$11,480,071	$4,464,472	$600,670	$747,044	$0	$1,856,862	$2,204,755	$21,353,874
2018	$12,331,568	$4,795,610	$2,063,453	$802,454	$5,154,650	$2,881,072	$2,368,285	$30,397,091
2019	$13,093,883	$5,092,066	$2,191,012	$852,060	$12,411,462	$4,000,459	$2,514,688	$40,155,630
2020	$19,894,169	$5,410,521	$2,328,036	$905,348	$13,219,967	$5,250,798	$2,671,955	$49,680,794
2021	$30,505,150	$14,083,913	$2,340,539	$910,210	$13,290,966	$6,284,521	$2,686,305	$70,101,603
2022	$36,666,374	$14,106,979	$2,408,784	$936,749	$13,972,920	$7,301,984	$2,690,705	$78,084,496
2023	$34,323,958	$13,197,203	$2,253,439	$876,337	$13,071,789	$7,773,286	$2,517,178	$74,013,190
2024	$36,807,058	$14,313,856	$2,416,459	$939,734	$14,017,442	$9,346,009	$2,699,278	$80,539,837
2025	$36,720,381	$14,280,148	$2,410,769	$937,521	$13,984,432	$9,656,640	$2,692,922	$80,682,812
2026	$36,035,592	$14,013,841	$2,365,811	$920,038	$13,723,640	$9,476,556	$2,642,702	$79,178,180
2027	$33,095,950	$12,870,647	$2,172,817	$844,985	$12,604,119	$8,703,496	$2,427,121	$72,719,135
2028	$34,886,882	$13,567,121	$2,290,396	$890,709	$13,286,170	$9,174,471	$2,558,460	$76,654,209
2029	$34,266,697	$13,325,938	$2,249,679	$874,875	$13,049,982	$9,011,376	$2,512,979	$75,291,525
2030	$33,602,827	$13,067,766	$2,206,095	$857,926	$12,797,156	$8,836,793	$2,464,293	$73,832,855

2031	$33,009,504	$12,837,029	$2,167,142	$842,777	$12,571,198	$8,680,762	$2,420,781	$72,529,195
2032	$32,390,643	$12,596,361	$2,126,513	$826,977	$12,335,514	$8,518,016	$2,375,397	$71,169,420
2033	$31,844,917	$12,384,134	$2,090,684	$813,044	$12,127,681	$8,374,502	$2,335,375	$69,970,338
2034	$31,326,826	$12,182,654	$2,056,671	$799,816	$11,930,374	$8,238,255	$2,297,381	$68,831,977
							Total	$1,192,731,724
							NPV 7%	$546,104,661
							NPV 3%	$837,260,304

Table TC52: HCE and Total Benefits of the Option 2 Tank Car, 2015-2034

Year	Aggregate Effectiveness	HCE Benefits, Mean Damages	HCE Benefits, 95th Percentile Damages
2015	0.009	$171,049	$769,447
2016	0.052	$5,823,870	$26,198,072
2017	0.150	$16,385,364	$73,707,850
2018	0.197	$21,713,895	$97,677,691
2019	0.245	$27,014,814	$121,523,323
2020	0.279	$31,455,674	$141,500,071
2021	0.307	$44,148,124	$198,595,733
2022	0.336	$49,095,129	$220,849,320
2023	0.355	$49,743,332	$223,765,190
2024	0.360	$50,478,071	$227,070,339
2025	0.361	$50,687,044	$228,010,382
2026	0.361	$50,687,044	$228,010,382
2027	0.361	$50,687,044	$228,010,382
2028	0.361	$50,687,044	$228,010,382
2029	0.361	$50,687,044	$228,010,382
2030	0.361	$50,687,044	$228,010,382
2031	0.361	$50,687,044	$228,010,382
2032	0.361	$50,687,044	$228,010,382
2033	0.361	$50,687,044	$228,010,382
2034	0.361	$50,687,044	$228,010,382
Total		$802,899,763	$3,611,760,861
7% Discount Rate		$365,168,143	$1,642,670,813
3% Discount Rate		$561,651,532	$2,526,530,849

Table TC53: Option 2 Tank Car Benefits Summary

	7% Discount	3% Discount
LCE Benefits	$546,104,661	$837,260,304
HCE Benefits, Mean	$365,168,143	$561,651,532
HCE Benefits, 95th Percentile	$1,642,670,813	$2,526,530,849

D. Requirement Area 3 – Speed Restrictions

Final Action: PHMSA is restricting the speed of HHFTs to 50 mph in all areas and 40 mph in HTUAs unless all tank cars meet the DOT-117 standard.

PHMSA is requiring a 50-mph maximum speed limit for HHFTs in all areas. PHMSA is also requiring a 40-mph speed limit for HHFTs within the limits of a *High-Threat Urban Area* (HTUA), unless all tank cars containing flammable liquids meet or exceed the new construction, performance, or retrofit standards for the DOT-117 tank car.

1. Determination of Need

Speed is a factor that may contribute to derailments. Speed can influence the probability of an accident, as slower speeds may allow for braking applications to stop the train before a collision. Speed also increases the kinetic energy of a train, resulting in a greater possibility of the tank cars being punctured in the event of a derailment. Under the current packaging requirement and until the new tank cars are fully in use, PHMSA believes reduced speed for HHFTs is warranted.

Further, despite existing voluntary action, additional regulatory action on the 50-mph speed limit is necessary because AAR OT-55-N is a recommended practice and, as such, does not carry the weight of law. A subscribing railroad can, without concern of a penalty, move these trains at speeds exceeding this voluntary industry standard and increase the energy and likelihood of catastrophic damage to tank cars involved in a train accident. Codifying this voluntary commitment will ensure that the benefits of these speed restrictions are realized indefinitely. Without codification of these requirements, the speed restrictions could be subsequently lifted prematurely and increase risk.

2. Action by the United States and Canada

U.S. Action

In the NPRM, PHMSA proposed to require a 50-mph speed restriction for HHFTs in all areas. This action aligns with the existing requirements imposed by AAR Circular No. OT-55-N. PHMSA believes that there will be no costs associated with a speed restriction of 50 mph, as this codifies current industry best practices.

PHMSA also proposed to limit any HHFT to a speed of 40 mph in select areas unless the tank cars meet the new DOT-117 standard. In the NPRM, PHMSA considered three Options for implementation of the 40-mph speed restriction and requested comments on which Option would have the greatest net social benefits and whether the 40-mph speed restriction is necessary. Further, in line with the NPRM, any HHFT that does not meet the braking requirements in the braking section would be restricted to 30 mph. This section will look at the costs associated with the slowdown of the rail network and the benefits from reducing the potential harm of HHFT accidents.

A train collision or derailment that occurs at 40 mph rather than 50 mph would be less severe.[137] PHMSA anticipates the efforts made by reducing the speed of trains with less safe tank cars and braking systems will prevent fatalities and other injuries, and limit the amount of environmental and property damage in an accident. PHMSA anticipates additional safety benefits will be realized as the tank car fleet meets the proposed integrity standards. The trains will no longer be subject to the speed restrictions discussed here, in but will accrue the benefits discussed in the tank car section, and the braking section. PHMSA believes that with enhanced braking, and greater car integrity, the risk from a derailment of a train that is authorized to travel at 50 mph is less than the risk from a train not so equipped with a maximum authorized speed of 40 mph. PHMSA believes the enhanced braking is likely to reduce the speed at which the train enters an accident from the maximum authorized speed, and to do so more effectively than conventional braking would allow. Once the tank cars have enhanced integrity and braking systems, they will be less likely to release product when involved in a derailment or collision. PHMSA expects reduced benefits attributable to speed restrictions as new tank cars make up a larger portion of the fleet and the reduction in risk is realized by the new tank cars. As a result, PHMSA phases out the speed restriction as the new tank cars are introduced.

Canadian Action

On April 23, 2014, Transport Canada issued an Emergency Directive restricting companies from operating a *key train*[138] at a speed that exceeds 50 miles per hour (mph).

3. Specific Comments

Comments addressing the proposed speed restriction focused mainly on the cost associated with reducing speeds from 50 mph to 40 mph. Comments from environmental groups and the concerned public generally supported a 40-mph speed limit in all areas, whereas comments from rail network users and operators generally supported a 40-mph speed limit in HTUAs, but not in other areas. The commenters affiliated with industry were concerned with the economic impacts of delays and reduced network fluidity.

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[137] Kinetic energy varies directly with the square of speed (velocity). [Kinetic energy = ½ Mass x (Velocity)^2] Forty mph is 80% of 50 mph. Assuming equal mass, the resulting change in energy is the square of the difference in velocity ($0.8^2 = 0.64$) or a reduction of 36% (1.00 - 0.64 = 0.36).

[138] "Key Train" means an engine with cars that includes one or more loaded tank cars of dangerous goods that are included in Class 2.3, Toxic Gases and of dangerous goods that are toxic by inhalation subject to Special Provision 23 of the Transport of Dangerous Goods Regulations; or that includes 20 or more loaded tank cars or loaded intermodal portable tanks containing dangerous goods, as defined in the Transportation of Dangerous Goods Act, 1992 or any combination thereof that includes 20 or more loaded tank cars and loaded intermodal portable tanks.

For example, the American Fuel & Petrochemical Manufacturers (AFPM) supports the proposal to establish a 40-mph speed limit in high-threat urban areas (HTUAS) unless the tank cars meet DOT-117 standards. AFPM has substantial concerns that any other speed limit would unduly restrict all types of rail traffic without any commensurate improvement in safety. The AFPM, quoting from an Association of American Railroads (AAR) presentation, states, "83 percent of the U.S. rail network is single track with passing track spaced every 5 to 50 miles." Thus, these tracks are shared by various types of trains, including passenger, premium, manifest, and unit bulk trains. AFPM is concerned that a blanket speed restriction would significantly restrict rail capacity and speeds for all these major traffic groups. If an overly restrictive speed limit were adopted, AFPM states shippers will require more tank cars to move the same volume of commodity, which may increase risk.

AAR notes that the Class I railroads committed to a 40-mph speed limit for crude oil trains in HTUAs in a February 2014 letter to Secretary Foxx and have since complied with the restriction. AAR asserts that expanding speed restrictions beyond the HTUAs would have a ripple effect on other rail traffic and degrade the fluidity of the rail network. Adverse impacts include reduced customer service, increased costs, and diversion of traffic to less safe and less environmentally friendly modes of transportation. Several freight railroads, including the Alaska Railroad Corporation, Burlington Northern Santa Fe, and Union Pacific, also reported that significant disruptions could occur if a uniform national speed limit were to be implemented. Passenger railroads commented that reducing the maximum allowable speed for crude oil trains beyond the voluntary USDOT-AAR agreement of 40 mph will increase freight train interference and reduce Amtrak's on-time performance (OTP). Poor OTP can have ongoing negative economic impacts for passenger trains, with operating costs, such as fuel, labor, and maintenance costs, increasing just as ridership and ticket revenues decline. Other commenters including shippers, manufacturers, freight forwarders, and logistical operations support the agreements between the AAR and DOT, but advocate for no further speed restrictions. Homeland Energy Solutions, LLC, an ethanol producer from Iowa, supports the 40-mph speed restrictions for trains that are transporting a continuous block of 20 or more cars containing crude oil through HTUAs, but strongly discourages any speed limits on ethanol trains.

Environmental groups refer to railroad accident records and research showing that serious accidents and extreme damage have resulted at speeds far lower than 50 mph and even lower than 40 mph. Some commenters have asserted that the only way to protect the public and avoid costly accidents is for PHMSA to impose a 40-mph speed limit in all areas and a 30-mph speed limit during the transition periods to higher tank car standards and ECP braking.

PHMSA reviewed all the comments and technical analyses submitted in response to the NPRM. Many commenters concerned with the risks of HHFTs propose nationwide speed restrictions below the 50-mph speed restriction. To assess the potential for such a speed restriction, the FRA uses simulation software to quantify the hours of delay that speed restrictions would impose on other trains, including passenger, intermodal, grain, and general merchandise trains. FRA found that the costs of a uniform HHFT speed restrictions below 50 mph, except in HTUAs, are cost prohibitive. Thus, this rule codifies the railroad's voluntary agreement to operate all HHFTs at 50 mph nationwide. In addition, this rule requires all HHFTs to travel at 40 mph within HTUAs unless all tank cars containing a Class 3 flammable liquid meet or exceed the retrofit or

performance standards or the new construction standards for the DOT-117. The 40-mph speed limit for HHFTs within the limits of HTUAs is in line with Option 3 proposed in the NPRM.

The Brattle Group (Brattle) questions the length of haul estimates for crude and ethanol shipments that informed the NPRM cost benefit analysis. In its analysis, Brattle finds that crude oil cars have longer trip times than ethanol cars. Brattle uses trip times to estimate the additional tank cars required, if uniform speed restrictions were imposed. Brattle finds that in 2012, the average rail shipment of crude oil traveled 1,397 miles, whereas the average rail shipment of ethanol traveled 950 miles. In deriving these estimates, it appears that Brattle utilized a 2012 waybill sample and a review of crude oil and ethanol origins and destinations by region, as delineated by the Bureau of Economic Analysis.

In determining its estimate for crude oil and ethanol movements, Brattle selected crude oil and ethanol records from the 2012 and 2013 Surface Transportation Board (STB)'s Confidential Waybill Sample, but only for those segments that occur on a Class I railroad. The STB Confidential Waybill Sample "total distance field" is calculated by routing traffic on a rail network between originating and terminating railroad stations[139]. The mileage is calculated by ALK Technologies, Inc., using PC Miler software and the Princeton Transportation Network Model.

In both years and for each Class I railroad, the combined average "total distance field" for crude oil traffic is 1,000 miles and includes over 2,000 trips, with a reported distance of 1,098 miles from the Bakken area. Other pairs of originating and terminating railroad stations range from 241 to 981 miles. Ethanol movements averaged 1,300 miles for 2012 and 2013 and include 2,700 moves by the western Class I railroads, which range in distance between 1,375 and 1,650 miles. The eastern Class I railroads conducted another 1,500 moves, averaging 850 miles in length.

E. Speed Restriction Alternatives

1. Restrict Speed to 50 mph in All Areas

Currently, there is no regulatory prohibition on speeds of HHFTs in excess of 50 mph (up to 79 mph). Nevertheless, for purposes of this rulemaking and analysis, PHMSA reasonably assumes that, in the absence of any regulatory action, all affected railroads will continue indefinitely to abide by the voluntary agreement currently in place to limit HHFT speeds to no more than 50 mph. Therefore, codification of the current 50 mph speed will result in the same level of damages occurring from derailments and the same probability of higher consequence events. As such, there will be no marginal costs or benefits resulting from this specific requirement.

[139] These are fields from the waybill sample database.

PHMSA believes the 50-mph speed limit is a current industry best practice adopted to reflect market pressures. Under these circumstances, this alternative would be, in effect, a status quo or "no action" alternative.

PHMSA asked several questions regarding AAR Circular No. OT-55-N in the September 6, 2013, ANPRM. Specifically, PHMSA asked if the Circular adequately addressed speed restrictions. The majority of the commenters indicated that the current self-imposed 50-mph speed restriction is acceptable. Further, during the recent industry Call-to-Action, the rail and crude oil industries agreed to voluntarily consider additional safety improvements, including speed restrictions in HTUAs, similar to the requirements that are established by the routing requirements in Part 172, Subpart I of the HMR.

2. Additional Speed Reductions

The laws of physics indicate that if an accident occurred at 40 mph instead of 50 mph, we should expect a reduction of kinetic energy by 36 percent. After consultations with engineers and subject matter experts, we can assume that this would translate to the severity of an accident being reduced by 36 percent. In addition, a slower speed may allow a locomotive engineer to identify a safety problem ahead and stop the train before an accident results, leading to accident prevention. With respect to prevention, PHMSA also notes that while reduced speeds will reduce the risk of accidents on net, some risks could increase under limited circumstances. For the purposes of this analysis, PHMSA only quantifies the benefits of mitigating the severity of accidents.

PHMSA uses a ten-mile speed differential in calculating an effectiveness rate for the 40-mph speed restriction options. This speed differential assumes that at the time of an accident, trains would be going 10 mph slower if the speed restriction were at 40 mph rather than 50 mph. Braking is often applied before an accident occurs, so the speed differential at the time of an accident that results from trains operating at maximum speeds of 50 mph and 40 mph could be different by more than 10 mph. Furthermore, congestion and/or other restrictions on speed may apply, which would also affect speed at the time of an accident.

FRA used simulation software to estimate the effects of a 40-mph speed restriction on crude oil and ethanol trains[140] on different types of train traffic traversing typical crude and ethanol corridors. The simulation software is based on long-standing, industry standard approaches to analyzing train movements along a network. Reference material regarding this simulation software has been placed in the docket for public review. The initial data entered into the simulation is based on data from the STB's 2012 Confidential Waybill Sample, the U.S. Energy

[140] Crude and ethanol trains are referred to as High-Hazard Freight Trains or HHFT's.

Information Administration, and observations from FRA inspectors in the field. Separate simulations were conducted for crude oil (STC Code 13111) and ethanol (STC code 28184).

The waybill sample's total distance field was used to estimate the average length of haul of both crude oil and ethanol for Class I railroads. FRA found that an average crude oil train travels over 1,000 miles and an average ethanol train travels over 1,300 miles on the Class I rail network.[141] However, FRA estimated that each type of train is on a transcontinental corridor for five-sevenths, or 71 percent, of each trip. FRA estimated the delay costs for each fuel train move by combining the results of two separate simulations to account for the different conditions applicable to entering and exiting the major transcontinental corridors. FRA assumed that three hundred miles of each trip, at the origin and destination, takes place on double-track territory with Centralized Traffic Control (CTC) signaling and six HHFTs operating at reduced speeds. FRA assumed that the remainder of the trip takes place on the major transcontinental corridors, also with CTC signaling, and with a range of one to ten HHFTs operating at lower speeds. In both cases, FRA assumed that track grade and curvature have minor effects on train speed. FRA expertise provides the basis for these assumptions.

During simulation, passenger and intermodal trains are granted priority, so that initially, fuel and general merchandise trains bear the majority of the delay. As the number of HHFTs increases, rail sidings fill up and all trains experience main line delay. Taking into consideration the close proximity of waybill originations, and assuming that crude oil/ethanol trains would be routed to move as quickly as possible to major corridors, FRA grouped crude oil and ethanol traffic into sixteen and six separate smaller corridors, respectively, for the first two-sevenths or 29 percent of the trip. FRA assumed crude oil trains travel across six major transcontinental corridors and ethanol trains are restricted to two.

Further, FRA assumed moderate traffic densities for each of the subdivisions on the corridor, but does not account for seasonal variation or extraordinary circumstances. As the number of fuel trains increased, net delay[142] increased exponentially.

This analysis provides an estimate of train delay at the corridor level. FRA does not have sufficient data to estimate the full impact of speed restrictions on the U.S. railroad network. To the extent that HHFTs traverse all the major U.S. railroad transcontinental corridors, the network

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[141] The average length of haul for each fuel type for the industry was calculated averaging the length of haul each origin-destination pair that occurred on the Class I railroad using 2012 Confidential Waybill. Interchange traffic on Class II and III rail networks was not included, as these railroads are not subject to this regulation.

[142] Net delay is the delay encountered in sidings, while stopped on the main line, due to schedule delay, or time spent waiting to be authorized to enter the territory.

impact could be significant. Other factors such as the supply and demand of crude oil and ethanol would also affect the outcome of this analysis.

The following table shows the total daily train hours of delay per corridor as estimated by FRA's simulation. The number of trains is the number of crude oil or ethanol trains traversing the corridor on a single day. For example, if one crude oil train on the representative corridor is subjected to a 40-mph speed limit, then all of the trains traveling the length of the corridor will experience a total of 84 hours of delay that day. Ten crude oil trains will result in 770 hours of delay for all trains on the corridor per day, while 10 ethanol trains will impose 1,522 hours of delay per day on all trains sharing the corridor.

Table S1: Time Impacts of a 40 mph Maximum Speed

Crude Oil Trains per Day	Daily Hours of Delay for All Trains	Ethanol Trains per Day	Daily Hours of Delay for All Trains
1	84	1	92
2	181	2	228
4	233	4	250
6	385	6	576
8	534	8	721
10	770	10	1,522

The beginning years of the restriction would be the most burdensome as the industry works to build or retrofit tank cars to the required specifications.

Restrict Speed to 40 mph in High-Threat Urban Areas (HTUAs)

PHMSA estimates that HHFTs traverse only two percent of the entire Class I rail network located within HTUAs. For this analysis, PHMSA assumes that only these track miles would have costs associated with them and affirms that any accident prevented or mitigated within these locations would have a greater impact on the total benefit pool than accidents in other areas. Population densities in HTUAs are 10 to 100 times greater than the average for smaller communities, and property values in HTUAs are much higher. As a result, an evacuation notice would affect more people in these areas, and damage to the transportation network, buildings, and other infrastructure would be higher. We estimate the effectiveness rates of the speed restriction in HTUAs by determining the value of a 36 percent reduction in kinetic energy attributable to speed restrictions along the entire rail network and then, multiplying this value by seven percent to remove the uncovered miles outside the HTUAs. After, we multiply the damages avoided by 3.5 (to account for the potentially greater harm that might result in these

HTUAs). [143] In subsequent years, we subtract the benefits attributable to the voluntary slowing of select crude oil trains. The effectiveness rates are presented in the table below.

PHMSA assumes the 40-mph speed restriction will reduce accident severity by 0.0882, which is the effectiveness rate from when the rule is initially implemented until the different sets of trains are DOT-117 compliant. Starting in 2017, the effectiveness rates are reduced based on the percent of the fleet that meets the DOT 117 standard.

Table S2. Speed Benefits Effectiveness Rates 40 mph, HTUA

Year	Effectiveness Rate
2015	0.0875
2016	0.0744
2017	0.0593
2018	0.0491
2019	0.0386
2020	0.0314
2021	0.0139
2022	0.0059
2023	0.0034

To calculate the total annual cost of delay from a 40-mph HHFT speed limit in all areas for HHFTs, PHMSA multiplied the daily cost of delay by the number of days in a week and by the number of weeks in a year. The total daily cost is determined by multiplying the total hours of delay by $500 per hour, which PHMSA estimates is the average cost of an hour of delay. The economic impact of slowing trains depends upon multiple factors including other types of trains, other train speeds, dispatching requirements, work zones, and topography. Looking at numerous variables, for purposes of this particular analysis, DOT estimated the average cost of a train delay to be $500 per hour. This cost estimate was determined by reviewing costs associated with crewmembers, supply chain logistic time delays based on various freight commodities, and passenger operating costs for business and other travel. PHMSA removes from the cost calculation the voluntary costs of slowing crude DOT-111 HHFTs to 40 mph in HTUAs.

Tables S2 and S3 demonstrate how the HTUA 40-mph speed limit costs are calculated for 2015 and 2016 before any train sets are compliant. The 2015 costs are reduced by 50 percent based on the assumption that the rule is not implemented until mid-year. During these initial years, the total delay hours for the 40-mph speed limit are calculated by multiplying the number of corridors by the daily hours of delay for all trains times the percentage of usage. This value is

[143] Reduced kinetic energy times percent rail network within HTUAs times the increased damages or .36*.07*3.5=0.0882

multiplied by the percent of the rail network within the HTUAs after removing voluntary compliance. Note that for voluntary compliance adjustment is only applied to crude oil trains. The Class I railroads are not slowing the ethanol trains within HTUAs as required by the rule.

Table S3 "number of hours" of delay column is determined by referencing Table S1 above. The "percentage of usage" column is based on the proportion of time that crude oil and ethanol trains spend on each type of track; the column shows that trains spend 29 percent of their time on start-end corridors and 71 percent of their time in the middle of the corridor. This ratio or percentage was calculated by considering the use of the rail network, defining two segments (i.e., the start/end of a corridor and the middle of a corridor), and then quantifying the proportion of time that traffic within our sample spent on each type of corridor. PHMSA assumed that the crude and ethanol routes would have similar start-middle-end ratios. The distances were based on the average corridor mileage for ethanol and crude oil trains.

Table S3: Cost of 40 mph Speed Limit, HTUAs Only, 2015 and 2016

	Number of Corridors	Number of Trains	Number of Hours	Percent of Usage	Voluntary Action Reduction	Total Hours[144]	Total Daily Cost
Crude Traffic at 40 mph							
Start-End	16	6	385	29%	4.57%[145]	43	$21,412
Middle	6	10	770	71%	4.57%	80	$40,148
					Total	123	$61,560
Ethanol Traffic at 40 mph							
Start-End	6	6	576	2/7	0%	69	$34,560
Middle	2	10	1,522	5/7	0%	152	$76,100
					Total	221	$110,660

[144] For the start-end corridors' crude oil traffic in year one, the daily hours of delay is calculated as follows: 16 corridors x 385 hours of delay x 2/7 percentage of usage x (100% minus 98% track miles covered reduction x 4.57% voluntary action reduction) = 43 total hours of delay per day

[145] PHMSA took account of the voluntary compliance with a 40 mph speed limit for crude oil in HTUA. The voluntary compliance is limited to 7 percent of trackage, the proportion of trackage in HTUAs, and is limited to those shipments made in cars that do not comply with CPC-1232, which are not subject to the voluntary compliance. PHMSA's estimate of the proportion of CPC-1232 cars is based on the proportion in effect at the effective date of the rule, which PHMSA estimates will be 35 percent of the HHFT fleet in 2015, in the NPRM we noted that 11 percent of the fleet would be CPC-1232 cars. For the purposes of this analysis the number of CPC-1232 cars is held constant. PHMSA believes that the voluntary compliance amounts to 4.57 percent of crude oil shipments. This percentage is deducted from burdens (i.e., costs) estimated below and is also used to reduce the benefit estimates.

Table S4: Cost of 40-mph Speed Limit	
HTUAs Only, 2015 and 2UAs Only, 2015 and 2016	
Total Daily Cost	$172,220
Total Weekly Cost	$1,205,540
Total Annual Cost 2015	$62,688,065
2015 = 0.5 * $62,688,065	$31,344,003

Table S5: Cost of 40-mph Speed Limit			
HTUAs Only			
	Undiscounted	**7% Discount**	**3% Discount**
2015	$31,344,033	$29,293,489	$30,431,100
2016	$52,873,753	$46,181,984	$49,838,583
2017	$42,158,808	$34,414,146	$38,581,282
2018	$34,881,209	$26,610,707	$30,991,503
2019	$27,464,645	$19,581,913	$23,691,244
2020	$22,333,952	$14,882,055	$18,704,333
2021	$9,892,017	$6,160,251	$8,043,115
2022	$4,174,247	$2,429,450	$3,295,189
2023	$804,595	$437,646	$616,655
Total	$225,957,259	$179,991,640	$204,193,004

Speed Analysis Limitations

This is a simplified analysis with several limitations. First, the analysis extrapolates from the geometric characteristics of a single 124-mile subdivision, which may not be representative. It is also possible that slower traffic along crude oil and ethanol corridors would lead to delays for the network overall. Further, the analysis does not take into account the potential diversion of rail traffic from the rail line on which the speed restriction occurs to other rail lines. Such diversion would slow down the traffic on other lines, but speed up the traffic on the line with the speed restrictions (and speed up the traffic diverted). Overall, the effect of the diversion would be to reduce delays, because the railroad would presumably only divert traffic if it reduced delays.

This analysis also does not take into account the possibility of rail traffic, particularly time-sensitive intermodal traffic, being diverted onto truck or other modes of transit because of rail delays. This could have adverse safety, environmental, and state-of-good-repair costs. PHMSA does not believe that the speed limitations and potential resulting delays will have a large effect on unit costs of shipping by rail, and therefore, any potential modal diversion would be minimal.

On February 21, 2014, the AAR signed a letter to DOT discussing the transportation of crude oil. One of the commitments that they made was:

"Railroad Subscribers commit to continue to adhere to a speed restriction of 50 mph for any Key Crude Oil Train. By no later than July 1, 2014, Railroad Subscribers will adhere to a speed restriction of 40 mph for any Key Crude Oil Train with at least one "DOT-111" tank car loaded with crude oil or one non-DOT specification tank car loaded with crude oil while that train travels within the limits of any high-threat urban area as defined by 49 C.F.R. § 150.3. For purposes of these commitments, "DOT-111" tank cars are those cars that meet DOT Specifications 111 standards but do not meet the requirements of AAR Circular CPC-1232 or any new standards adopted by DOT after the date of this letter."

In the Call-to-Action, there was voluntary compliance on the transportation of crude oil; however, this did not include jacketed CPC-1232 tank cars, which comprise around 35 percent of the fleet. Therefore, except for jacketed CPC-1232, PHMSA does not anticipate any new costs associated with the slowdown of traffic in a HTUA when transporting crude oil.

F. Requirement Area 4 – Braking

Final Action: PHMSA is requiring HHFTs to be equipped with Advanced Braking Systems.

PHMSA is requiring HHFTs to be equipped and operated with either a *two-way end-of-train* (EOT) device or a *distributed power* (DP) system, or travel at 30 MPH or less. By January 1, 2021, any HHFUT transporting one or more tank car loaded with a Packing Group I flammable liquid will be required operate using an ECP brake system that complies with the requirements of 49 CFR part 232, subpart G. All other HHFUTs (i.e. trains consisting of Packing Group II or Packing Group III flammable liquids) must be equipped with operative ECP brake systems by May 1, 2023, when traveling in excess of 30 mph.

Determination of Need

The two-way EOT device includes two pieces of equipment linked by radio that initiate an emergency brake application command from the front unit located in the controlling locomotive, which then activates the emergency air valve at the rear of the train. The rear unit of the device sends an acknowledgment message to the front unit immediately upon receipt of an emergency brake application command. A two-way EOT device is more effective than conventional brakes because the rear cars receive the emergency brake command more quickly.

DP is a system that provides control of a number of locomotives dispersed throughout a train from a controlling locomotive located in the lead position. The system provides control of the remote (rearward) locomotives by command signals originating at the lead locomotive and transmitted to the remote locomotives.

ECP brake systems simultaneously send a braking command to all cars in the train, reducing the time before a car's pneumatic brakes are engaged, compared to conventional brakes. The system also permits the train crew to monitor, in real time, the effectiveness of the brakes on each individual car in the train and provides real-time information on the performance of the entire braking system of the train. ECP brake system technology also reduces the wear and tear on

brake system components and can significantly reduce fuel consumption. All cars in a train must be equipped with wiring that allows the ECP brake signal to be relayed through the entire train before a train can operate in ECP brake mode.

Braking systems reduce kinetic energy and therefore help prevent and mitigate the effects of train accidents. FRA has conducted research on the effectiveness of advanced brake signal propagation systems, which provide improved brake signal propagation time. PHMSA and FRA used that research to inform the need for advanced brake signal propagation systems requirements, particularly on longer, heavy trains carrying large quantities of flammable liquid.

In the NPRM, PHMSA and FRA provided data produced by Sharma & Associates showing a 36 percent effectiveness rate of ECP brakes over conventional air brakes as expressed in number of cars punctured. In March 2015, Sharma & Associates performed additional modeling that takes into account the comments received after publication of the NPRM. See "Letter Report: Objective Evaluation of Risk Reduction from Tank Car Design & Operations Improvement – Extended Study," Sharma & Associates, March 2015. This updated, purpose-built model from Sharma & Associates confirms that ECP brakes provide substantial safety benefits in emergency braking situations compared to air brakes, two-way EOT devices, and DP systems. While a comprehensive discussion of effectiveness rates is provided in March 2015 Letter Report, some highlights are provided below.

Puncture hazards result from a variety of factors, including operating conditions, speed of the train, and the type of tank car involved, which can make it difficult to objectively quantify the overall safety improvement that ECP brakes provide. The updated model provided by Sharma & Associates encapsulates a variety of factors in an effort to assess the real-world impact of the various braking alternatives considered in the NPRM. The Sharma model is validated by the general agreement between the actual number of tank cars punctured in 22 hazardous material derailments and those predicted by the model.

The March 2015 Letter Report from Sharma & Associates used the most probable number of tank cars punctured to evaluate the benefits of the tank car enhancements, brake systems, and speed. The derailment scenarios were simulated for a 100-car train at different speeds with the first car subjected to a brief lateral force to initiate the derailment. At the point of derailment, Sharma & Associates applied a retarding force to all the cars that was equivalent to an emergency brake application. For a train with conventional air brakes, Sharma & Associates modeled a brake initiation of 12 percent net braking ratio, which represents an emergency brake application, propagated from the front (point of derailment) to the rear of the train. For a train with a two-way EOT device or a DP locomotive at the rear of the train, the emergency brake signal propagation was initiated at both ends of the train. For a train with ECP brakes, the model has all cars simultaneously receiving the braking signal with a brake ratio of 12 percent. As reflected in Table BR1, for DOT-117 and DOT-117R tank cars, the ECP braking system was consistently the top performer in terms of preventing the most cars punctured, while two-way EOT devices and DP systems with a locomotive at the rear consistently out-performed conventional air brake systems.

Table BR1: Most Likely Number of Punctures: 100-Car Train, with POD at Head End				
Tank Car Type	**Speed, mph**	**Conventional Brakes**	**2-way EOT (DP: lead + rear)**	**ECP Brakes**
7/16" TC128, 11 gauge jacket, 1/2" full-height head shield	30	4.7	3.9	3.3
	40	8.0	7.1	5.3
	50	12.2	9.8	9.1
9/16" TC128, 11 gauge jacket, 1/2" full-height head shield	30	3.8	3.2	2.6
	40	6.6	5.9	4.3
	50	10.2	8.2	7.6

Based on the analysis in the 2015 Letter Report from Sharma & Associates, PHMSA and FRA believe that ECP brakes, in isolation, can be expected to reduce the number of cars punctured by up to 30 percent compared to conventional air brake systems (minimal variation based on train speed). In addition, a two-way EOT device or DP locomotive at the rear of the train will reduce the number of cars punctured by up to 16 percent. These numbers are reflected in Table BR2 for DOT-117 and DOT-117R cars.

Table BR2 : Risk Improvement Due to Braking with POD at Head-End 100 Cars Behind POD					
		Most-Likely Number of Punctures			**% Improvement Due to ECP Brakes Only Relative to 2-way EOT**
Tank Type	**Speed, mph**	**Conventional Brakes**	**2-way EOT (DP: lead + rear)**	**ECP Brakes**	
7/16" TC128, 11 gauge jacket, ½" full-height head shield	30	4.7	3.9	3.3	15%
	40	8.0	7.1	5.3	25%
	50	12.2	9.8	9.1	7%
9/16" TC128, 11 gauge jacket, ½" full-height head shield	30	3.8	3.2	2.6	19%
	40	6.6	5.9	4.3	27%
	50	10.2	8.2	7.6	7%

The ECP brake system always provides an advantage over conventional the air brake system in terms of likely number of tank cars punctured. This is true regardless of the location of the derailment within the train because the brakes are being applied to each car in the train at the same time. However, a number of commenters suggested that the scenarios modeled by Sharma & Associates may overstate the effectiveness of ECP brake systems because its model focused

on measuring derailments at the front of a train. As a result, FRA conducted further analysis based on the simulations of derailments at different points in the train. FRA's simulations considered derailment at locations with 100, 80, 50, and 20 cars trailing the point of derailment. A polynomial fit of the resulting derailment and puncture results data from the simulations enabled FRA to evaluate the results of a derailment at any location in the train through interpolation and extrapolation. The results of the evaluation indicated that POD does affect the estimated number of cars punctured for any of the simulated brake systems, including a reduction in the estimated number of cars punctured for trains operated in ECP brake mode. This is expected given that if a derailment occurs at the 50th car in a train rather than the first car in the train, there are fewer cars to derail after the POD. In every simulation, the ECP brake system reduced the number of cars punctured compared with two-way EOT devices and DP systems with the locomotive at the rear. See Tables BR3 and BR4.

Table BR3 : Most Likely Number of Punctures: 100-Car Train, with POD Distributed Throughout Train

Tank Type	Speed, mph	Conventional Brakes	2-way EOT DP (lead + rear)	ECP Brakes
7/16" TC128, 11 gauge jacket, ½" full-height head shield	30	3.4	2.96	2.34
	40	6.2	5.62	4.19
	50	8.54	7.18	6.55
9/16" TC128, 11 gauge jacket, ½" full-height head shield	30	3.03	2.66	2.12
	40	5.6	5.1	3.8
	50	7.8	6.6	6.0

Table BR4 : Risk Improvement Due to Braking, with POD Distributed Throughout the Train

		Most-Likely Number of Punctures			% Improvement Due to ECP Brakes Only Compared to 2-way EOT
Tank Type	Speed, mph	Conventional Brakes	2-way EOT (DP: lead + rear)	ECP Brakes	
7/16" TC128, 11 gauge jacket, ½" full-height head shield	30	3.4	2.8	2.6	35.4%
	40	6.8	6.2	4.65	24.4%
	50	9.3	7.92	7.2	8.0%
9/16" TC128, 11 gauge	30	2.8	2.4	2.2	20.3%
	40	5.6	5.1	3.8	25.7%

Table BR4 : Risk Improvement Due to Braking, with POD Distributed Throughout the Train					
jacket, ½" full-height head shield	50	7.8	6.6	6.0	8.5%

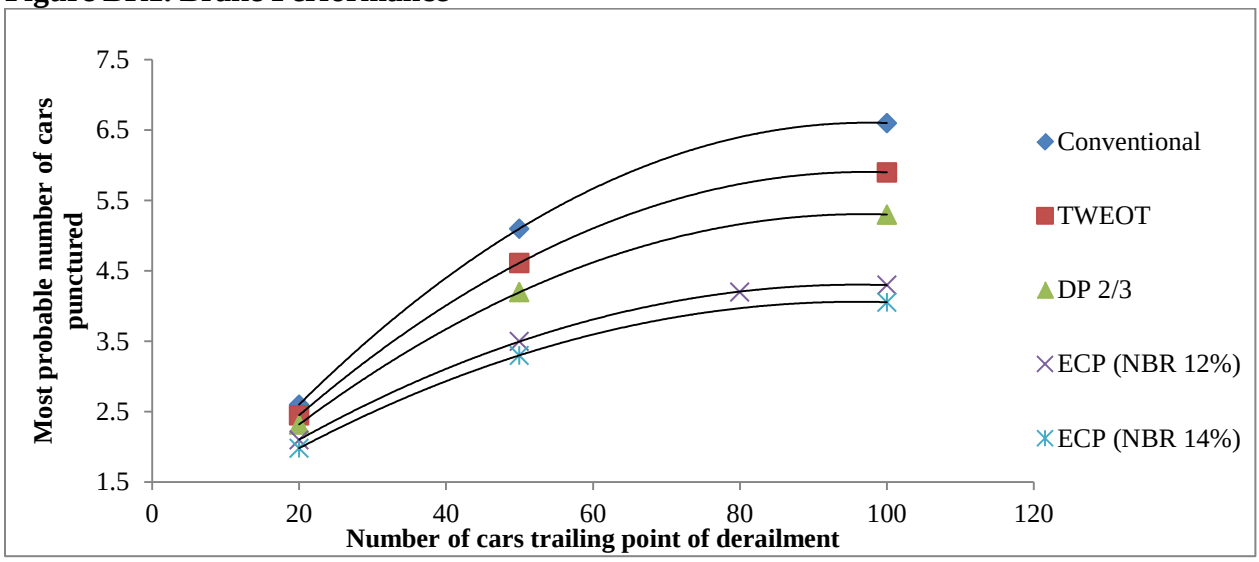
The results of these simulations in the March 2015 Letter report from Sharma & Associates and the FRA analysis of the data show that advanced brake signal propagation systems reduce the rates of puncture in derailing tank cars relative to the conventional air brake system, with ECP braking systems demonstrating the best overall performance. According to the March 2015 Sharma & Associates analysis, the risk reduction benefits for ECP brake systems are most pronounced for long trains. As trains become shorter, the differences in puncture rates become diminished between ECP brakes and two-EOT devices or DP systems with a locomotive at the rear because of the limited time needed to initiate emergency braking.

While PHMSA and FRA are establishing a requirement to implement ECP brake systems for certain operations, we recognize that the railroad industry may develop a new brake system technology or an upgrade to existing technology that is not addressed in 49 CFR part 232, subparts E (for two-way EOTs) and G (for ECP braking systems). This rulemaking is not intended to "lock in" the status quo with respect to ECP braking systems as the only form of brake system that can be used on unit trains operating in excess of 30 mph while transporting 70 or more loaded tank cars of flammable liquids. In the event that a new technology is developed, railroads should apply to FRA to obtain special approval for the technology pursuant to part 232, subpart F.

FRA also conducted simulations to better understand the effect on energy dissipation and stopping distance of different brake signal propagation systems; conventional brakes, two-way end of train devices, 2/3 DP configurations, and ECP brakes. The simulations were developed by Sharma & Associates to study the dynamics and energy levels under a variety of operating conditions. The parameters evaluated by the model are provided in Table BR5:

Table BR5: Parameters Evaluated in the FRA's Purpose Built Model		
Parameter Category	**Subcategory**	**Description**
Brake System	**Conventional**	**Without End-of-Train Device**
	TWEOT	Two-way end-of-train device capable of initiating emergency from the rear based on signal from lead locomotive
	DP 2/3	Distributed power locomotive at a location at or near 2/3 back in the consist from the lead locomotive
	ECP (NBR 12 percent)	Electronically controlled pneumatic brakes with a set net brake ratio of 12 percent. This is the same brake ratio as Conventional, TWEOT and DP 2/3 systems in the purpose built model.

Figure BR1. Brake Performance



The results of these simulations indicate the benefits of an increased net braking ratio, a decreased brake signal propagation time and train stability during an emergency brake application relative to the conventional brake system. Thus, additional requirements for advanced brake signal propagation systems are feasible for addressing HHFT risk.

1. Action by the United States and Canada

U.S Action

In the NPRM, PHMSA proposed to require advanced braking systems (electronic controlled pneumatic brakes (ECP), distributed power (DP), and two-way end of train (EOT) device to reduce the number of cars and energy associated with train accidents as follows:

For all three tank car Options, by 10/1/15 HHFTs must be equipped and operated with two-way end of train (EOT) braking devices or distributed power (DP), or travel at 30 mph or lower.

Applicable only to the proposed tank car Option 1 (i.e., the PHMSA and FRA designed car), all HHFT tank cars built after October 1, 2015, and HHFT tank cars retrofitted to the PHMSA and FRA designed car standard, must be equipped with ECP brakes. Trains comprised entirely of PHMSA and FRA designed cars, except required buffer cars, would have been required to operate in ECP mode, or travel at no greater than 30 mph.

Canadian Action

We are not aware of any Canadian completed or proposed actions on this topic.

2. Specific Comments

The NPRM, and the RIA for the NPRM, requested comments and input on the rulemaking and its supporting documents. The following provides a summary of the comments received that pertained to the economic issues, and how those comments were addressed.

Effectiveness of ECP Brakes

PHMSA and FRA received many comments stating the ECP brake system technology was not an effective braking system, or that it was not a proven technology. These commenters noted that DP systems were just as effective as ECP brakes. Many of the comments were directed towards the computer simulations that were run for the NRPM. They believed that the simulations of merely 80-car trains overstated effectiveness of ECP brake systems, and that the models looked at only derailments starting in the first car of the train. However, in the NPRM, PHMSA and FRA looked at 100-car trains. Commenters also stated that pileups are not as likely as the models used in the NPRM indicated. PHMSA and FRA refined analysis of benefits addresses this comment.

FRA has run numerous additional simulations for the final rule. These simulations considered derailment at locations with 100, 80, 50, and 20 cars trailing the point of derailment. A polynomial fit of the resulting derailment and puncture results data from the simulations enabled FRA to evaluate the results of a derailment at any location in the train through interpolation and extrapolation. The results of the evaluation indicated a reduction in the estimated number of cars punctured for trains operated in ECP brake mode. (Comparing a two-way end of train device/DP in the rear to ECP brakes)

Modeling

The majority of the discussion of the modeling can be found in the tank car section of this analysis. However, some of the safety benefits corresponding to ECP braking were debated by commenters during the comment period. Their comments noted that the TEDS model[146] used by PHMSA and FRA in the NPRM, derived different results than the TOES model,[147] which was the model used by the AAR.

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[146] Train Energy and Dynamics Simulator (TEDS) is a longitudinal train dynamics and operation simulation software developed by Sharma & Associates for the Federal Railroad Administration.

147 Train Operation and Energy Simulator (TOES) is a train action model developed for and licensed to AAR-member railroads.

Simulations are only as good as the assumptions used to drive the program. Both TEDS and TOES are based on the laws of physics. The TEDS simulator was compared and validated against the TOES simulator and essentially provides identical results in response to the same input assumptions. TEDS was developed through FRA's Research & Development Program only because AAR was unwilling to make TOES available outside its membership.

In the NPRM, we based effectiveness of brake systems, in part, on TEDS results. To reach a conclusion on the effectiveness of various brake systems, we correlated the effectiveness of ECP brakes, calculated using the Sharma model, to an energy dissipation curve calculated using TEDS. We then calculated the areas under the energy dissipation curves for a number of brake systems. Differences in the areas under the curves were then used to calculate the effectiveness of the alternative brake systems. For instance, the difference in area between the ECP brake curve and the conventional brake curve is twice the difference in the area between the two-way end-of-train device (TWEOT) curve and conventional brake curve. Therefore, the effectiveness of TWEOT is half that of ECP brakes. The effectiveness and benefits in the final rule are not based on this relationship. Instead the effectiveness is calculated using the Sharma model exclusively. TEDS is used to determine the time history of the brake signal for the alternative brake systems. These results are then used as input to the LS-Dyna model of the 18 different derailments in the Sharma model.

In its comments, the AAR provided a study using TOES. The study provides simulation results in the form of energy reduction and number of car reaching the point of derailments. AAR also "reproduces" the stopping distance recorded in three derailments. However, none of the results are from an actual simulation of a derailment. The model simply calculates the speed of the train during the braking and the stopping distance. The train does not "derail" in the TOES model, rather it simply slows to a stop. Using the difference in the deceleration, AAR calculated the relative energy dissipation. The difference in stopping distance was used to determine the reduction in the number of cars reaching the point of derailment. Simulations to reproduce stopping distances were performed by applying an opposing (the direction of movement) force they referred to as a blocking force. The blocking force is a surrogate for the force applied to the trailing cars by the derailing cars and minimized the braking force needed to stop the train. These results were provided in an effort to refute the effectiveness basis in the NPRM. Specifically, AAR asserts a blockage force was not included in the TEDS results provided in the NPRM. While this is true, it is irrelevant. As stated above, the TEDS results are not the basis for the effectiveness in the final rule.

In the final rule, the Sharma model is used to calculate effectiveness and blockage force is implicit in the model. In fact, knowing that the event recorder from the Aliceville, Alabama, derailment showed that the rear locomotive traveled about 1240 feet, we compared that to the LS-Dyna derailment simulations (not TEDS). We checked ten of the 18 runs in the 100-car, 40 mph, EOT braking set and found that in most of the runs the distance the rear car traveled was in the range of 1250 to 1300 feet. The LS-Dyna runs had 10 more cars (and 1 less locomotive) than the Aliceville, Alabama train, and started at 40 mph rather than 39 mph. Adjusting the Dyna distance for reduced initial speed brings the range down to 1190 - 1235 feet. So, the rear car distance traveled in the Dyna simulations matched the Aliceville locomotive's event recorder data with a difference of less than four percent. This shows that in spite of all the potential variations, our derailment simulations closely matched the reality as evidenced by the event

recorded download. The results also validate that PHMSA's and FRA's choice of friction coefficients was reasonable (the AAR also asserted the range of friction factors used in simulating the derailments was inappropriate), and the results further indicate how the LS-Dyna simulations implicitly include the blockage force.

Any comparison of results derived from AAR's TOES to those from TEDS is inappropriate because TEDS results are not the basis for the effectiveness in the final rule. The Sharma model is used to calculate the effectiveness. The Sharma model is superior to TOES for three reasons. First, the Sharma model simulates a derailment. TOES simulates slowing and stopping of a train on the tracks. Second, the Sharma model quantifies effectiveness in the form of the number of punctures. TOES indicates energy reduction and stopping distance relative to a stationary point of derailment. These are a poor corollary to the outcome of a derailment. Energy is necessary but insufficient to quantify damages. Other factors, such as location of impact and size of impactors are of equal importance to energy. None of these items are included in TOES. Third, the results of the Sharma model enable us to calculate the effectiveness of the brake system, speed at derailment, and the tank car design. The effectiveness of each variable can be calculated individually or in combination with one or both of the other variables. TOES is not capable of such analysis.

The Sharma model was developed specifically to calculate the number of punctures likely to occur in a derailment and to enable PHMSA and FRA to calculate the effectiveness of the tank car design, speed at the time of derailment, and brake system. Moreover, we were able to evaluate the effectiveness of these variables assuming a particular type of train make-up, in this case a unit train. Another model with similar capabilities does not exist. A letter report describing the rationale and methodologies employed by the model was posted in the docket to provide an opportunity for public review. A number of comments related to the model were received. These comments are addressed elsewhere in the RIA and Final Rule.

Additionally, after the NPRM, Sharma and Associates published a paper describing the model. The paper has been reviewed. The model generally has received very positive feedback. A few instances are outlined below.

- The paper was presented at the ASME Joint Rail Conference. The paper was reviewed anonymously, and there was positive feedback as well as some constructive criticism. All the feedback and criticism was incorporated into the final letter report which is referenced in the RIA and Final Rule.
- The paper has already been reviewed and accepted for publication at the International Heavy Haul Conference to be held in June 2015.
- The paper was reviewed by FRA Research and Development personnel and their feedback has been incorporated into the final letter report.
- The paper was presented to and well-received by personnel at Transport Canada as well as personnel at the Volpe National Transportation Center.
- An overview of the work was presented at the NTSB Tank Car forum and folks from NTSB have also seen published versions of the paper. All feedback has been positive.

In the July 2014 letter report that supported the NPRM, Section 5: Preliminary ECP Simulations, the authors provided the following caveat to the reported results related to ECP brakes.

> *Nonetheless, given that this is based on a limited simulation set, the results could be a bit optimistic, and should be taken with a grain of salt. Once a larger number of simulations are complete, it is anticipated that the percent improvement due to ECP would likely drop to about 25%, or about a 5-6 mph performance advantage at a 40 mph derailment speed.*

This has been the focus of a number of comments. As stated, the authors understood that the reported results were based on a limited number of simulations that could be run in the time available to inform this rulemaking. The results of the July 2014 letter report were based on 12 derailment simulations while the effectiveness reported in the final rule is based on 18 simulations. The reported effectiveness of ECP brakes in the NPRM was about 36 percent. As the authors predicted this result was optimistic and the effectiveness was likely closer to 25 percent, which is very close to the results indicated in the final rule.

Dynamic Braking

Dynamic braking is not a substitute for train air brakes (electronically controlled or otherwise), but a supplementary system that provides an additional means of train-speed control. However, AAR asserts that many of the benefits claimed in the analysis of the NPRM for wheel savings and fuel savings are currently realized through use of dynamic braking, so the marginal benefit of ECP brakes should be much lower. AAR provided limited data from the current coal trains that operate in the United States with ECP brakes indicating that ECP brakes are utilized only 11 percent of the time that brakes are employed. The remaining 89 percent of the time, dynamic brakes are used. Although PHMSA and FRA did not incorporate the use of dynamic braking into the NRPM analysis, we have adjusted for it in this final rule.

AAR uses the data from coal trains and recommends that fuel and wheel benefits should be reduced by 85 percent. Our analysis, however, indicates that AAR's reasoning behind this recommended adjustment is flawed. Although railroads use dynamic braking for much of their braking, dynamic brakes, in some ways more than conventional pneumatic brakes, create significant in-train forces and can be damaging to both the rolling stock and the rail structure.

The ability to use ECP brakes on top of the dynamic brakes further improves fuel efficiency by as much as five percent above compared to using dynamic braking alone, depending on the

routes and railroad practices.[148] In response to the AAR comments, PHMSA and FRA accept a 50 percent reduction in the fuel efficiency benefits in its analysis. However, fuel benefits are not always easy to measure and FRA believes this likely understates fuel efficiency benefits. For instance, a railroad using ECP-equipped trains may decide to trade fuel efficiency for higher average speeds or longer, heavier trains (as evidenced by the Australian experience). Additionally, AAR's contention about an 85 percent reduction in costs related to wheel wear does not account for corresponding stress being placed on the rail when a train employs dynamic braking alone. AAR also does not account for the additional efficiencies that will occur when railroads take advantage of the coordinated use of ECP brakes with dynamic brakes, which are discussed below.

Railroads will continue to experience brake-induced wheel wear where pneumatic brakes are used, but if the railroads rely on dynamic braking they will experience increased rail wear, with the attendant increased risk of broken rail accidents and increased track maintenance costs. PHMSA and FRA estimate that the use of dynamic braking in conjunction with ECP brakes would reduce the dynamic brake induced rail wear by at least 25 percent based on Canadian Pacific's (CP) experience.[149] Further, in spite of initial increases in thermal mechanical shelling due to heavy "experimenting" by train crews during the familiarization phase, CP found a four percent improvement in average wheel life.[150] Once operations "settle in," improvements in wheel life may reach ten percent, thus reducing the estimated wheel wear benefit by 75 percent instead of the 85 percent estimated by AAR.

Most of the rail and infrastructure wear caused by dynamic braking occurs due to power braking. Power braking also uses excess fuel and creates poor in-train forces. PHMSA and FRA expect that ECP brakes will provide further benefits in these areas as the use of ECP brakes with dynamic braking can eliminate power braking. Further, ECP brakes can be operated at a more steady speed nearer the speed limit by using the graduated release feature of ECP brakes rather than applying full release and waiting for the brakes to recharge.[151] This allows for a more optimum use of dynamic brakes. Modulating the speed over the dynamic braking with ECP brakes also greatly reduces in-train forces by applying the brakes evenly through the train rather than just at the locomotive.

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[148] Wachs, K. 2011. Electronically-Controlled Pneumatic (ECP) Brake Experience at Canadian Pacific, *Presented to the International Heavy Haul Association (IHHA) Conference, Calgary, AB.*, p. 4

[149] Wachs, K.,p. 4

[150] Wachs, K., p 6

[151] Wachs, K., p. 3

Further, as more employees are properly trained in using ECP brakes, railroads will begin to fully experience the maximum benefit available by using a combination of ECP and dynamic braking. We recognize that this change in operating culture will take time. This is one of the reasons why any benefits associated ECP brakes on a given HHFUT are not accounted for until one year after that HHFUT is estimated to be equipped with ECP brakes. However, computer devices, such as LEADER and Trip Optimizer,[152] are proliferating within the United States rail network that permit engineers to better manage the train speed and use of braking. This promotes efficient usage of ECP brakes during the initial period when engineers are learning the best use of the new technology, and as locomotive engineers become more comfortable with this braking system, the benefits of ECP brakes blended with dynamic braking will be greater than those estimated in this analysis.

Finally, while dynamic braking has an important role in controlling the speed of modern freight trains, FRA does not consider it to be a primary braking system for the purposes of meeting the power brake requirements of 49 U.S.C. §20302 or the requirement of 49 CFR §232.103. These require that a primary brake be capable of stopping the train with a service application from its maximum operating speed within the signal spacing existing on the track over which the train is operating. Dynamic braking does not contribute to reducing emergency stopping distances and does not have a fail-safe element to stop the train if the integrity of the dynamic brake fails in use. Both conventional pneumatic brakes and ECP brakes meet these statutory elements.

Cost of ECP on Tank Cars

Several stakeholders commented that the cost to equip tank cars with ECP brakes in the NPRM was too low. PHMSA and FRA used two different cost estimates in the NPRM. For any car that would be retrofit, PHMSA and FRA assumed the cost would be $5,000. For cars that were considered new construction, the cost would be $3,000. In the comment period, PHMSA and FRA received comments that the costs associated with ECP for tank cars would range from $5,300 - $15,000.

PHMSA and FRA reviewed these comments and have updated their estimate. One of the manufacturers of tank cars provided PHMSA and FRA with an estimate of $7,000, while another commenter, Railway Supply Institute (RSI), provided FRA with an estimate of $7,300 for a newly constructed tank car and $7,800 for a retrofitted tank car. In its December 19, 2014 letter to PHMSA and FRA, RSI provided a detailed total per car labor and material cost estimates for installation for new and modified tank cars. Based on review of the comments and professional judgment, PHMSA and FRA are using an average estimate of $7,633 that relies on RSI's estimates and assumes that approximately one third of the ECP fleet would be new construction tank cars and two thirds of the ECP fleet would be comprised of retrofitted tank cars. This

[152] http://www.up.com/aboutup/corporate_info/sustainability/preserve_environment/fuel_efficiency/index.htm

estimate may be high to the extent that for the crude oil fleet the industry may equip ECP brakes significantly more on new cars than on those in the existing fleet.

Cost of ECP on Locomotives

PHMSA and FRA received comments from several stakeholders that the cost to retrofit locomotives in the NPRM was too low. Some commenters did not see a cost for the locomotive in the NPRM. However, in the NPRM, PHMSA and FRA estimated that it would cost around $79,000 to retrofit a locomotive with ECP brakes. The Association of American Railroads (AAR) noted that this cost would be closer to $88,300 per locomotive.

Class I Railroad's locomotive purchasing projections indicate that over 1,000 locomotives will be purchased in 2015. PHMSA and FRA believe that the railroads will continue this rate over the next 6 years, and the railroads would be able to allocate a portion of new locomotive purchases towards locomotives equipped with ECP. For new locomotives, the ECP add-on over an electronic based locomotive air brake (i.e. CCB-2 or Fastbrake) is estimated, by FRA Motive Power and Equipment Division to cost $40,000 per locomotive.

Additional Locomotives

PHMSA and FRA received comments regarding the number of locomotives that the NPRM had indicated would need to be equipped with ECP brakes to support the proposed ECP brake requirement. In the NPRM, PHMSA and FRA estimated that 300 unit trains would be used in the peak period, and that 900 locomotives would be retrofit with ECP brakes to accommodate three locomotives per train. Some of the commenters noted that all locomotives in the rail industry would need to be equipped with ECP brakes to meet the proposed requirements. Some commenters further explained that if an ECP-equipped locomotive was out-of-service there would not be sufficient replacement locomotives equipped with ECP brakes, thereby causing a bottleneck. Others noted that switching locomotives would also need ECP brakes.

After the NPRM, PHMSA received comments from RSI that updated the forecast of the number of carloads that would be originated. Based on this update, PHMSA and FRA made adjustments and are now estimating that the maximum number of HHFUT on the general network at any given time would be 633. Not all locomotives would need to be retrofit since the equipment with ECP brakes is part of a captive fleet, and therefore the locomotives would be part of that captive fleet. Although the majority of these trains operate with three locomotives, PHMSA and FRA are assuming 2,532 ECP-equipped locomotives (four per train) will be required to meet the final rule requirements for ECP brake operation, which would accommodate for out-of-service locomotives or any additional locomotives needed to operate the HHFUT's with ECP brakes.

One of the major railroads currently operating an ECP-equipped subset of their fleet has purchased additional runaround cables used to by-pass a locomotive that may not be equipped for ECP braking. PHMSA and FRA assume that other railroads would follow this business practice, and purchase one set for each ECP-equipped locomotive in service. This would prevent any bottlenecks or slowdowns from occurring if an ECP-equipped locomotive was not available. With these runaround cables, any locomotive not equipped with ECP brakes could be used as a non-controlling locomotive on the HHFUT, providing the required power to operate the train.

PHMSA and FRA envision that ECP-equipped tank cars will be on an overlay system, as opposed to a stand-alone ECP brake system. The overlay system would allow any locomotive to move these cars in non-ECP mode, assuming they are only traveling 30 mph if they constitute a HHFUT. This would allow switching locomotives to avoid having ECP brakes installed to comply with the rule.

Equipping Short Line Railroad Locomotives

The American Short Line and Regional Railroad Association noted that it believes that the short line railroads would need to equip their locomotives. PHMSA and FRA believe that the majority of short line railroads affected by this rule already transport these commodities on Class III track, which is subject to speed restriction of 30 mph. Since this analysis assumes that tank cars will be equipped with overlay systems, any non-ECP-equipped locomotive from a short line railroad should be able to haul these tank cars. Notwithstanding, FRA expects that the Class I railroads will supply unit crude oil and ethanol trains that will stay intact, including the locomotive (through the use of pooled power arrangements), from origin to destination. Further, FRA anticipates that the Class I crews will continue to operate the train over the smaller railroad's line pursuant to trackage rights or other agreement. Therefore, if a shortline or regional railroad were to receive a crude oil or ethanol unit train at its interchange with a Class I railroad, FRA anticipates that the locomotive (and the Class I operating crew) will pass through interchange with the rest of the train. For the same reason, there will not be additional training costs for the crews of short line railroads.

ECP-Equipped Tank Cars Cannot be intermixed

PHMSA and FRA received comments that an ECP-equipped tank car could not be intermixed with other cars in a train consist. These commenters also believed that cycle times would be increased, as special movements would need to be made to rescue stranded ECP-equipped cars. This would add additional operational costs. PHMSA and FRA have verified with subject matter experts in ECP brakes and determined that an overlay system would be able to be intermixed with non-ECP brake-equipped cars carrying other commodities; however, we do not expect that these cars will be regularly switched into mixed commodity trains. In addition, if a railroad decides to operate with stand-alone ECP brakes, §232.609(h) permits the operation of stand-alone ECP brakes on cars in a conventional train as long as the conventional brakes are 100 percent effective, and the total percentage of effective brakes in the trainset are at least 95 percent. Stand-alone ECP-equipped cars still have vent valves, and can propagate emergency brake signals. Therefore, unless a large number of defective ECP-equipped cars need to be moved, it will be difficult to 'strand' ECP cars. As noted above, PHMSA and FRA have limited the number of tank cars that will need to be equipped with ECP brakes to those cars in a HHFUT that operates in excess of 30 mph. This will minimize the number of times these cars will need to be intermixed, as PHMSA and FRA believe that these trains will stay together for long periods in order to meet the demand for service.

Fleet Management

The PHMSA and FRA analysis assumes that shippers have the ability to predict or control whether a given tank car will be used in manifest train service or unit train service. With respect to unit train service, shippers will typically contract with a railroad to provide these services and will be aware that its tank cars are being operated in unit train service. In fact, shippers currently advertise their ability to have unit train service which implicitly is a benefit to the shippers' customers.[153] Agweek reported that "[u]nit trains are considered more efficient and have access to more destinations."[154] However, some commenters noted that the identification of what type of service—manifest or unit train—a shipper's tank car may be transported in may be a difficult to discern. These commenters argue that it could result in shippers equipping more tank cars with ECP brakes, in order to maintain their current level of fleet flexibility.

Shippers have fleet managers responsible for the logistics, maintenance, and repair of owned and leased tank cars. Business units within each shipper manage the use of the owned or leased tank cars based on the commodity shipped. The shippers purchase or lease tank cars based on the anticipated demand for each business unit. The cars are leased or purchased in groups. The fleet managers or business units assign cars to the specific service to meet supply chain demands. Under the current practices, the fleet managers keep these cars in unit train service. This will be easier as the fleet matures—currently because of the shortage of tank cars, shippers of crude oil and ethanol sometimes cobble together fleets from a variety of sources to meet demand. Based on current energy production forecasts, these cars will likely remain in unit service over the length of their leases or, if owned, over the expected life of the cars. Some shippers also use specialized fleet management companies.

Tank car ownership has been consolidating recently as shippers are opting to lease rather than purchase tank cars. Shippers then contract with railroads to pick up and deliver tank cars containing their products. This service may be in mixed freight, or by unit train. These contracts are usually longer term deals—ranging from five to ten years in length—particularly for unit train operations because both shippers and railroads benefit from locking in the contract terms for major commodity shipments that are likely to stay steady for a multi-year period. A vital consideration of these contracts is whether it is for unit train operations. A contract for unit train service is expected to be of sufficient length to pay for the unique design of the equipment for the service. However, there is flexibility in contracting for rail service, and we expect that this flexibility will allow shippers and carriers to coordinate in a way that helps resolve any fleet management issues. For example, new and retrofitted tank cars may not have ECP brakes

[153] http://www.csx.com/index.cfm/customers/commodities/agricultural-products/services/ethx-express-ethanol-delivery/

[154] "Ethanol plants depend on rail service improvement to prevent shutdowns." Pates, M. 10/27/14. Agweek.com, http://www.agweek.com/event/article/id/24322/publisher_ID/80/

installed initially, and a shipper may decide to add ECP brakes to a whole train at once. Shippers could upgrade equipment to accommodate for ECP brakes when it becomes clear that equipment will be used in a unit train that is covered by the rule because, unlike with tank car retrofitting, ECP brakes can be installed on tank cars in a yard or other less-sophisticated equipment facility.

Carriers and shippers, through their fleet management, often work to ensure that a unit train stays together for the length of the contract. Coal trains that operate as unit trains are a prime example of this. When a wheel set needs to be replaced on a hopper car that is in a unit coal train, Union Pacific (UP), in particular, stops the entire train and brings machinery to lift the individual car and replace the wheel set while keeping the train together. FRA granted an inline wheel replacement waiver to UP to accommodate this. BNSF has also discussed applying for these waivers in two different locations. When this occurs on manifest trains, the car is typically set out and the train continues on without the car.

Although the shippers and carriers already have fleet managers, PHMSA and FRA have included an extra cost to account for any additional expenses associated with managing the ECP brake system fleet. In our analysis, we have estimated 8,000 man hours in the second year of this rule as a means of accounting for any burden that would be encountered. PHMSA and FRA believe that this is conservative estimate as these positions already exist and the shippers are already managing these small captive fleets. As the crude oil and ethanol fleets mature and permanent unit train sets are established, managing tank cars that make up unit trains will become easier. Moreover, managing cars in unit train services is easier than cars in mixed freight service because the tank cars in unit train service for crude oil and ethanol tend to stay together for an extended period of time.

Reliability and Technological Readiness

AAR has argued that ECP brakes are not reliable and that ECP brakes are an unproven technology that is not ready for wide spread deployment. In making these assertions, AAR relies on its own evidence—developed after publication of the NPRM—while discounting all other sources. PHMSA and FRA have reviewed AAR's evidence, and we have also reviewed FRA studies, analyzed the results of ECP brake system waiver programs, and examined the results of ECP brake operations in other countries. In PHMSA and FRA's view, the evidence firmly establishes that ECP braking is a "mature technology" that can, among other things, reduce derailment frequencies.[155] Therefore, while AAR now contends that ECP braking technology is not ready or unreliable, the actions of AAR and its members outside the context of this

[155] "Assessment of freight train derailment risk reduction measures: A4 – New Technologies and Approaches", Report for European Railway Agency, Report No. BA 000777/05, April 19, 2011, at 9, http://www.era.europa.eu/Document-Register/Documents/DNV%20Study%20-%20Final%20A4%20Report%20-%2020110419%20-%20Public.pdf.

rulemaking in updating AAR Standard S-4200 and continuing to use ECP brake systems in revenue service while also pursuing regulatory relief on brake inspections indicate otherwise.

ECP brakes have been operated in North American fleets since at least 1998, and these fleets have seen varying degrees of success during this time period. PHMSA and FRA recognize that there have been hurdles in the deployment of ECP brakes (e.g. diversion of capital away from ECP brakes to PTC and software issues contributing to crosstalk). However, the technology has continued to improve since 1998 and carriers are in a better position now to ensure that ECP brakes are successfully implemented.

In 2008, FRA promulgated a rule to establish a regulatory process by which railroads could implement ECP brakes. The ECP brake rule incorporates by reference AAR's 2007 ECP brake standards developed by it standards making body. As recently as July 2014, AAR updated its ECP brake standard to resolve issues identified during ECP operations and improve the standard. Also, in 2014, BNSF and Norfolk Southern (NS) began moving forward with a pilot program waiver that allowed the carriers to jointly operate an ECP-equipped train that is permitted to travel up to 5,000 miles between brake inspections.[156] Setting aside AAR's alternative assertions, the carriers' pursuit of this waiver is evidence that they consider ECP brake systems reliable. Otherwise, they would not be pursuing a regime that would allow for fewer inspections of ECP-equipped trains, which would need to be justified with data from the pilot program. FRA has granted this waiver and is currently assessing the efficacy of extending the interval between brake inspections to 5,000 miles on ECP-equipped trains. The success of these pilot programs indicates that this technology is working well, and is ready for further deployment. If ECP braking was not a success, these pilot programs would end, and no additional carriers would seek waivers. As previously discussed, NS would not have expanded their ECP routes within the last three years if this system was not reliable.

AAR has argued that its member railroads have experienced longer delays in train consists operating in ECP brakes versus conventional braking. Its contention is that its members have experienced delays in their ability to respond to en route failures on ECP braking systems because of the lack of available equipment to make routine repairs and lack of personnel to make the repairs. AAR uses this information to argue that ECP brakes may be too complex and not reliable. However, AAR is looking at these issues through the wrong end of the lens. According to a representative from New York Air Brake, the issue with ECP brake systems "is not reliability, but rather, availability of power and shops."[157] These are issues that can arise with any new technology, but they do not evidence a problem with the technology itself. The problem is solved by increasing the availability of ECP braking equipment and training a workforce to

[156] FRA currently allows brake inspections to take place every 3,500 miles on ECP-equipped trains instead of the traditional 1,000 miles or 1,500 miles for long haul trains operating with pneumatic brakes. See 49 CFR 232.607.

[157] William C. Vantuono, "The Science of Train Handling", Railway Age, June 2012, at 25-26.

handle ECP brake issues as they arise. PHMSA and FRA have taken into account the need for investment in these areas and have factored in costs that are designed to mitigate the cause of these types of delays.

The North American railroads have not trained enough employees on the use and maintenance of ECP brakes because of the very small number of trains that have been operated with ECP brakes. If a carrier has not invested sufficiently in training and an ECP-equipped train has any mechanical issues, there likely will be delays associated with locating an employee trained on ECP brakes maintenance and repair who could travel to the site to assess and correct the problem. For example, on Canadian Pacific Railway there was a train stranded for about 18 hours in 2012 during the holiday season, and the employees who were on-duty were not familiar with the ECP technology. ECP brakes are expected to be deployed over 68 percent of the general rail network. As a result, training will be more widespread, which should overcome any potential issue similar to what CP experienced from occurring. With ECP-equipped trains operating over such a large portion of the network, there will be an incentive for rail carriers to provide necessary training on ECP brakes for broad section of its operating and maintenance personnel in order to ensure that these trains are handled correctly and maintained in a timely manner. PHMSA and FRA have included training costs in the analysis for all locomotive engineers, conductors, and carmen that would work on any part of the HHFUT routes. This accounts for 68 percent of the mentioned employees. By properly training these employees, problems can be reviewed and corrected in a timely fashion, thereby limiting the amount of out-of-service time.

Some railroads seem to have experienced delays resulting from not having sufficient equipment on hand to address normal operational issues. The extent of this problem is not well-researched, but there is some evidence that ECP brakes are often tabbed as the culprit for delays even when they are not the actual cause of the delay. This was reported in the Sismey and Day study, which noted that, "[t]his is not unique to ECP as it tends to happen whenever new technology or operational aspects are introduced."[158] Notwithstanding, PHMSA and FRA do not question that lack of ECP brake equipment can cause delays. For example, at one point BNSF and NS had an insufficient ratio of ECP-equipped locomotives to ECP-equipped trains. NS, which currently operates six of ECP-equipped trains, solved this issue by outfitting locomotives with run-around cables, which allows any locomotive to be used as a secondary unit to power a train. To account for a sufficient level of extra equipment, PHMSA and FRA have conservatively assumed four locomotives will be outfitted with ECP brakes per trainset, when only three are necessary to power a trainset. We have also assumed that each locomotive will be outfitted with run around cables.

[158] pg. 229.

Trains equipped with ECP brake systems in the United States typically operate using stand-alone systems. However, to minimize delays, we have assumed in our analysis that the tank cars for HHFUTs will be equipped with more expensive overlay systems. The overlay system is more expensive than the stand alone ECP brake system, but it provides an extra layer of flexibility in operations by allowing the tank cars to be used in a train with either braking system. This will allow some shortline carriers that operate these trains at 30 mph or under to use their own locomotives and use conventional air brakes. Shortlines could also opt to use "through" trains under an arrangement between interchanging railroads in which trackage rights are granted and the initial carrier operates the train to the destination using their equipment and crews. This approach is used with Class I railroads. For example, the NS's ECP locomotives stay with the trainset even when operating on BNSF track with BNSF crews.

PHMSA and FRA recognize that delays will likely occur during the initial implementation of the technology, but there is no reason to believe that these delays would be any longer than the delays that have taken place with the roll-out of any other new technology, such as distributed power. Further, an overly ECP braking system could allow continued safe operation in the event of an ECP braking failure.

FRA currently allows brake inspections to take place every 3,500 miles on ECP-equipped trains instead of the traditional 1,000 miles or 1,500 miles for long haul trains operating with pneumatic brakes. In 2014, BNSF and NS began moving forward with a pilot program waiver that allowed the carriers to jointly operate an ECP-equipped train that is permitted to travel up to 5,000 miles between brake inspections. Setting aside AAR's alternative assertions, the carriers' pursuit of this waiver is evidence that they consider ECP brake systems reliable. Otherwise, they would not be pursuing a regime that would allow for fewer inspections of ECP-equipped trains, which would need to be justified with data from the pilot program. FRA has granted this waiver and is currently assessing the efficacy of extending the interval between brake inspections to 5,000 miles on ECP-equipped trains. The success of these pilot programs indicates that this technology is working well, and is ready for further deployment. If ECP braking was not a success, these pilot programs would end, and no additional carriers would seek waivers. As previously discussed, NS would not have expanded their ECP routes within the last three years if this system was not reliable.

AAR has raised crosstalk and interoperability as the two primary technological issues that affecting the ability of trains to operate in ECP brake mode. "Crosstalk" occurs when a signal—usually from a passing train—interrupts the signal of an ECP-equipped train causing the train to go into emergency mode. After further investigation into this problem, the ECP brake manufacturers were able to resolve this by updating the ECP brake software program. The new software incorporates a unique code established between the locomotive and the end of train device at initialization. This unique code attaches to all messages within a train and allows two passing trains to continue to operate in ECP brake mode without any interference, as these trains can no longer communicate with each other. This fix requires a railroad that is operating equipment using an older version of ECP braking software to update that software for all freight cars and locomotives that operate with ECP brakes, but the fix has proven effective in eliminating crosstalk problems.

As evidence of the effectiveness of this solution, the software update was incorporated into the AAR Standard S-4200 in July 2014.[159] Any new ECP-equipped freight car or locomotive that has this update should not experience any crosstalk problems. Australian railroads currently are updating their ECP braking software. In the United States, NS has updated its ECP-equipped coal cars; however, its locomotives have not yet been updated. It is expected that NS will update its locomotives in 2015 at the same time its ECP-equipped locomotives are taken to repair shops for PTC upgrades. PHMSA and FRA do not have specific information on BNSF, but any equipment operating in the United States under AAR Standard S-4200 is expected to be updated before July 2016.[160] Once railroads have incorporated the software updates, they will be able to operate more efficiency by avoiding delays related to crosstalk.

Given that the ECP braking requirements in this rulemaking do not take effect until January 1, 2021, PHMSA and FRA expect that the latest software will be included on all HHFUTs that operate in excess of 30 mph. As a result, by the time that ECP brakes are required for HHFUTs, PHMSA and FRA expect that the crosstalk problem will be fully resolved.

Some commenters also have raised the issue of interoperability between the ECP equipment of various manufactures. This argument is misplaced regarding ECP equipment in full interchange service. The issue of interoperability between varying manufactures has been addressed by AAR's ECP standards since 2008. As mentioned earlier, these standards have been updated as recently as July 2014. PHMSA and FRA believe this issue has been raised by commenters using pre-2008 equipment or equipment that has not been updated to comply with the current version of this standard, and therefore those comments do not represent a realistic concern.

Limited Suppliers of ECP Braking Systems

Several commenters noted there are only two companies that manufacture and supply ECP brakes. They discussed that the majority of products they sell are for railroads overseas, and the available supply of ECP brakes will not be sufficient to equip the tank cars. One of the commenters also felt that a lack of suppliers would cause an increase in ECP braking system prices, as the ramp-up period to be ECP-equipped is too fast.

First, there are only two major suppliers of conventional brake equipment in the United States at this time, and within normal commercial constraints, they are sufficiently supplying the car and locomotive building industries. In the NPRM, PHMSA and FRA estimated that every tank car

[159] The S-4200 update of July 2014 also helped to improve system performance of the trainline connectors and correct the brake cylinder pressure requirements.

[160] "Subject:Implementation: Revisions to AAR MSRP Section E-II, ELECTRONICALLY CONTROLLED BRAKE SYSTEMS, S-4200, S-4210, S-4230 and S-4250", Circular Letter C-12156, Association of American Railroads, July 24, 2014.

(130,000 +) would be equipped with ECP brakes regardless of if it would be part of a unit train. The NPRM also limited the phase in time to a three-year period. As PHMSA and FRA have limited the number of tank cars that would need to be equipped with ECP brakes, the number of tank cars has decreased to 60,231 cars. PHMSA and FRA believe that ECP brake component manufacturing capacity will accommodate this demand over a six to eight -year period, which was increased in the final rule. PHMSA and FRA believe that this ramp up of production could be done with minimal capital investments for the ECP brake manufactures.

Separate Fleets

The AAR commented that having a separate ECP brake system fleet would be daunting and difficult to manage. PHMSA and FRA acknowledge that initially, an extra burden could be required to manage these assets associated with ECP braking systems. The railroads and shippers may have employees who already manage the crude oil and ethanol fleets. The additional cost to determining the best way to manage these fleets would be realized in the first year of operation. PHMSA and FRA included the costs of an asset manager to help account for the difficulties of managing separate fleets. These costs can be seen further in the analysis.

Training and Wages

In the NPRM, PHMSA and FRA assumed that 9,000 employees would need to be trained in the use of ECP brakes. Some of the commenters noted that this estimate was too low because all crewmembers and carmen would need to be trained. PHMSA and FRA believe that the commenters' estimate is too high, but note that the original estimate in the NPRM was low.

PHMSA and FRA looked at the routes of the HHFUT's to determine how many crews could be affected. Using the waybill sample, FRA determined that approximately 68 percent of the total ton-miles were on routes that had crude or ethanol unit trains. PHMSA and FRA adjusted the estimate to include 68 percent of the total crews as the other 32% of crews work on track that does not carry crude oil or ethanol. Based on these assumptions, around 18,000 engineers and 27,000 conductors would receive additional training. PHMSA and FRA also included 6,500 carmen in the training pool. Training duration was also adjusted to reflect actual experience by railroads currently conducting such training.

The AAR noted that there was an underestimation of wage rates, as they believe that engineers' wages should be $73.10 and conductors' should be $62.16. PHMSA and FRA used the 2012 STB's Wage Statistics of Class I railroads to determine the number of Class I railroad employees who would be impacted by the proposed rule. PHMSA and FRA also incorporated a 75 percent overhead cost.

Burden of Costs

PHMSA and FRA received numerous comments debating what entities would bear the costs of this regulation. The various comments noted that the cost would be borne by the rail carriers, car lessors, or car owners. PHMSA and FRA recognize that this rule will have significant costs and that all of these entities will be incurring implementation costs. In the final rule, PHMSA and FRA have tried to minimize the costs to all stakeholders by only requiring ECP brakes on

HHFUT, which should also ensure the highest safety and business benefits return per unit equipped.

Additional Maintenance Costs on Tank Car

During the comment period, PHMSA and FRA were informed of additional costs associated with the use of ECP brakes. The commenters noted that some components, such as batteries and electrical cables, would need to be replaced every five years. PHMSA and FRA have included the replacement costs that would take place during a tank car's normal maintenance services and have included these costs in our analysis.

Out-of-Service Time

RSI commented that PHMSA and FRA did not account for the amount of time a car would be out-of-service for retrofitting for ECP brakes. PHMSA and FRA determined that there is no additional time necessary for including ECP brakes in a retrofit. That is, subject matter experts indicate that ECP brakes can be included in a retrofit without adding out-of-service time. If a bottleneck in retrofits occurs, the outfitting of ECP brakes can be done at any rail car repair facility. This will help to reduce the amount of time a car is out-of-service. PHMSA and FRA also note that fewer cars will have to be equipped under the final rule than would have had to be equipped under the NPRM.

Timeline for Implementing ECP Brake Systems

Numerous commenters asked for clarification regarding the timeline for implementation of ECP braking systems. In the NPRM, PHMSA and FRA expected all tank cars (including ECP-equipped) to be retrofit within three years. PHMSA and FRA reviewed the comments for the tank car portion of the rule, and developed a new phase-out period. The ECP brake requirement begins on January 1, 2021 for any HHFUT operating in excess of 30 mph that contains one or more loaded tank car of a Packing Group I flammable liquid. For all other HHFUTs, the ECP brake requirement would begin on May 1, 2023. This would provide a longer timeline for retrofits to occur.

ECP Brakes Accident Prevention

PHMSA received comments noting that ECP brakes would not be able to prevent any accidents. Like many of the elements of this rule that will mitigate the consequences of an accident, PHMSA and FRA also recognize that the majority of ECP braking system benefits will also help to reduce the severity of accidents. However, FRA specifically looked for derailments (accident types) in which train handling was the cause of the incident. Accidents such as "string line" derailments could also be avoided with ECP brakes. In addition, certain equipment-caused (e.g., wheels) accidents could be prevented. The benefit section of the analysis further discusses this topic.

Background

On March 9, 2011, AAR, on behalf of its members and the Tank Car Committee (TCC or Committee), jointly petitioned PHMSA and Transport Canada (TC) to establish new standards for DOT Class 111 tank cars used to transport hazardous materials in packing groups I and II. The petition (P-1577), which was an outgrowth of a TCC executive working group, proposed new design standards and specifically recommended no modification for existing tank cars. The AAR agreed to forward the petition to PHMSA on behalf of the TCC because of the Committee's unanimous decision.

On May 10, 2011, FRA met with the Railway Supply Institute's (RSI) Tank Car Committee to discuss improvements to tank cars used for the transportation of crude oil in unit trains. FRA requested this meeting to discuss improvements to tank car safety specific to crude oil given the recent increase in the demand for these cars. The main intent of the meeting was to spur discussion about innovative solutions that improve tank car safety for future changes in the hazardous materials transportation supply chain. The advent of increased shipments of crude oil in unit train quantities provided an avenue to discuss safety enhancements prior to a major tank car build. FRA suggested a number of potential safety enhancement technologies such as spray-on thermal protection, manway redesign, and tank car design improvements (rounding edges of components) for consideration by the tank car builders/owners. The meeting resulted in the RSI members offering to develop an industry standard (non-regulatory) in collaboration with the AAR, the Renewable Fuels Association (RFA), Growth Energy, and the American Petroleum Institute (API). This collaborative effort was conducted through TCC's Task Force T87.6. The T87.6 Task Force carried out technical analyses and generated information for tank car safety improvements, including findings on alternative brake propagation systems. The advanced brake signal propagation systems considered in the T87.6 Task Force meetings included conventional air brakes, ECP brakes, DP systems, and two-way EOT devices.

TEDS was used to study the dynamics and energy levels of trains under a variety of operational conditions. Specifically, TEDS was used to determine the stopping distance and the rate of dissipation of kinetic energy (KE) of a generic 100-tank car train on level tangent track equipped with the candidate brake signal propagation systems. The simulations were used to determine the relative performance of the different systems. The model was validated using brake signal propagation data from Wabtec and data from a BNSF test performed in 2008.

This modeling tool was then used to determine the remaining energy to be dissipated and the speed at selected locations in the train when that tank car reached a defined point specified as the Point of Derailment (POD). By comparing the results for each technology, assumptions were made for the difference in number of cars reaching the POD, remaining kinetic energy of all of the cars in the train at a set time interval, and conditional probability of release (CPR) of hazardous material on the train.

Informed by a 2008 FRA rule on ECP braking systems,[161] the task force estimated unit costs for ECP to be $4,500 per car for new construction with an overlay (dual-use) system, $5,000 per car for retrofit with an overlay system and $44,000 per locomotive. The group found:

Based on the simulation results and analysis of the data it was concluded the alternatives considered provided marginal benefits. Moreover, the identified obstacles to implementation represent a considerable time and cost investment and the predicted benefits would not be realized for months or years in the future. As such, this working group will not make a recommendation related to alternative brake signal propagation systems.[162]

In the September 6, 2013, ANPRM, PHMSA specifically requested comments pertaining to advanced brake signal propagation systems (ECP brakes, DP systems, and two-way EOT devices) to reduce the number of cars and energy associated with derailments. In addition, FRA and RSAC have considered and evaluated the usefulness of advanced brake signal propagation systems.

The totality of these efforts show that FRA and DOT have gathered information from multiple sources and conducted extensive research to better understand the effect on energy dissipation and train stopping distance of different brake signal propagation systems. The evidence collected is inclusive and supports the regulatory change.

Fleet Forecast

In the NPRM, PHMSA and FRA forecasted that 133,010 tank cars would be required to meet the demand of crude oil and ethanol production levels in the peak year (2020) of the twenty-year period analyzed. This demand was primarily based on: (1) comments that RSI made in the ANPRM regarding the demand for tank cars and (2) the US Energy Information Administration's (2014 EIA Forecast) forecast production for US crude oil and ethanol.[163] PHMSA and FRA received minimal comments after the publication of the NPRM addressing this estimate. One of the few comments that were made came from RSI.

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[161] For the FRA final rule, https://www.federalregister.gov/articles/2008/10/16/E8-22549/electronically-controlled-pneumatic-brake-systems

[162] T87.6 Task Force Summary Report, PHMSA-2012-0082-0012, http://www.regulations.gov/#!documentDetail;D=PHMSA-2012-0082-0012

[163] Source of both crude oil and ethanol production forecast was the Energy Information Administration's Annual Energy Outlook 2013.

RSI projected that as the production of crude oil increases, other modes transporting oil (such as pipeline or barge) would already be at capacity. This would cause rail to increase their market share of the transportation of crude oil. RSI projects that there will be 419,099 carloads of ethanol in 2024, which will be its peak year. Crude oil's peak year will be in 2021 when 1,131,980 carloads will be produced. RSI's comments noted that around 160,000 tank cars would be required for this North American service: 30,000 for ethanol and 130,000 for crude oil.

AAR Annual Report

Every year, the Association of American Railroads (AAR) produces an Annual Report of Hazardous Materials Transported by Rail. Exhibit 2 of the 2013 edition of this report lists the top 125 hazardous commodities, measured by carload. In 2013, the AAR reported that there were 483,701 crude oil tank cars originating in North America, with 401,813 originating in the US and 81,888 in Canada. This gives us average shipments per car of 11.2[164] per year for crude oil. In 2013, the AAR reported that there were 290,710 alcohols NOS (ethanol) tank cars originating in North America, with 290,709 originating in the US and one in Canada. This gives us average shipments per car of 10.8[165] per year for ethanol.

These two utilization estimates (shipments per tank car per year) are likely too low resulting in an artificially high estimate of cars needed in the future to meet demand. As noted in RSI's comments, any tank car that shipped at least one carload of this commodity during the year would be included in the crude oil tank car fleet numbers. RSI does not account for partial year service for tank cars, which leads to an underestimated average utilization rate. In the first 4 months of 2014, over 600 tank cars moved from other services into crude oil service, creating artificially low utilization rates for these 600 cars since they are listed separately and not pro-rated to reflect partial-year service in each commodity category. In addition, the UMLER database shows over 4,100 cars built during the course of the year in 2013. Not adjusting for the partial year service of these cars also results in underestimates of the average utilization rates, as they were not in-service the entire year. However, for the purposes of this analysis, FRA is using the RSI's conservative (artificially low) estimate that was calculated using the data provided by the Brattle Group.

Using RSI's projected peak carloads for ethanol service results in 419,099 carloads transported by roughly 30,000 tank cars, which would translate to 14.0[166] shipments per car in the peak year. This is an increase of 29.6 percent from 2013. Using RSI's projected peak carloads for crude oil service results in 1,004,852 carloads transported by roughly 96,590 tank cars, which would

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[164] 483,701 (Carloads of Crude oil) / 43,288 (number of cars used in 2013) = 11.174

[165] 290,710 (Carloads of Ethanol) / 27,024 (number of cars used in 2013) = 10.757

[166] 419,099 (RSI Forecast of carloads of Ethanol in 2024) / 30,000 (RSI estimate of number of cars used) = 13.970

translate to 10.4[167] shipments per car in the peak year. This shows a 7.1 percent decrease in utilization rate (efficiency) from 2013.

If we were to predict the number of tank cars required by looking at the 2013 AAR average shipments per car of crude oil, and using RSI's forecast, industry would need 101,069 tank cars. Even using a conservative AAR estimate, FRA believes that RSI has overestimated the cars required for crude service.

Unit Trains (HHFUTs)

PHMSA and FRA received many comments discussing the costs associated with ECP brakes. In the NPRM, it was proposed that every HHFT tank car would be equipped with ECP brakes. The final rule mandates that only HHFUTs would be required operate in ECP brake mode.

PHMSA and FRA have considerably narrowed the ECP brake requirement from that proposed. The final rule will require the use of ECP brakes only on certain long unit trains of Class 3 flammable materials, classified as HHFUT operating at greater than 30 mph. An HHFUT is any train comprised of 70 or more loaded tank cars containing class 3 flammable liquids. This maximizes the return on investment for ECP brakes, as only tank cars that are regularly used in unit trains will be equipped with them. The 70-car threshold should exclude manifests made up of mixed freight trains hauling ethanol and focus only on traditional unit trains of both commodities. This closely aligns with FRA's research into per unit crashworthiness, which estimated that the safety benefit of a 100-car unit train with ECP brakes is approximately equivalent to 64-car train using a two-way EOT device. The mandate for operating HHFUTs with ECP brakes would be January 1, 2021 or May 1, 2023, depending on the consist of the train (if there is one or more tank car load of Packing Group I flammable liquids, the earlier date applies).

Crude Oil Traffic

The peak crude oil production from the 20-year period analyzed is in 2021 with an estimated 1,131,980 carloads. Using RSI's 10.4 shipments per year average, the rail industry would need 96,590[168] tank cars to meet forecasted demand for crude traffic.

From the 2013 waybill sample, FRA estimated that 84 percent of crude oil shipments traveled in trains of 70 or more crude oil carloads. FRA believes that these trains are unit trains, traveling from the loading facilities to the oil refineries and back. The experience of FRA's regional staff

[167] 1,004,852 (RSI Forecast of carloads of Crude in 2021) / 965,90 (RSI estimate of number of cars used) = 10.403

[168] 1,004,852 (Carloads) / 10.4 (Utilization rate) = 96,590 (Number of cars required)

is that substantial quantities of crude oil and ethanol are currently being transported in unit trains, and many companies advertise the transportation of these commodities as being shipped in unit trains. We can then assume that 84 percent of the shipments in 2021 would travel in unit trains giving us 844,076[169] carloads for HHFUTs and 160,776[170] carloads for non-unit trains.

Ethanol Traffic

The peak ethanol production for the 20-year period analyzed is an estimated 419,099 carloads in 2024. RSI believes that the current 30,000 cars would be able to transport those carloads. Looking at the 2013 waybill sample, FRA determined that 0.285 percent of ethanol shipments traveled in trains of 100 or more carloads. However, the waybill also found that roughly 47 percent of the ethanol trains transported 70 or more tank cars. After discussions with ethanol stakeholders and FRA regional staff, PHMSA and FRA believe that all of these trains were operating as unit trains. In the peak ethanol year, there would be 197,400[171] carloads for HHFUTs and 222,600[172] carloads for non-unit trains.

Utilization Rates for HHFUT

In the NPRM, PHMSA and FRA noted that a unit train would travel 220 miles in one day. This translates to a 14-day cycle time for an average unit train. No comment was made to dispute this assumption. FRA also talked to individuals at the loading facilities, who indicated that a 14-day cycle time would be accurate for crude oil unit trains. A news article[173] stated that cycle time from the Bakken has improved from 23-24 days down to 18-19 days for one railroad. Bridger LLC comments indicate a 15-day round trip cycle time between North Dakota and the East Coast. Finally, FRA reached out to its regional inspectors, who estimated that the crude oil from the Bakken regions would have cycle times ranging from 6-14 days, with an average cycle time of 10 days. The cycle time would vary based on if the shipment were going to the east coast, gulf region other locations such as Kansas City. In this analysis, PHMSA and FRA wanted to

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[169] 1,004,852 (carloads of crude) * .84 (percent of carloads on unit trains) = 844,076 (carloads of crude on unit trains)

[170] 1,004,852 (carloads of crude) – 844,076 (carloads of crude on unit trains) = 160,776 (carloads of crude not on unit trains)

[171] 419,099 (carloads of ethanol) * .47 (percent of carloads on unit trains) = 197,400 (carloads of ethanol on unit trains)

[172] 419,099 (carloads of ethanol) – 197,400 (carloads of ethanol on unit trains) = 222,122 (carloads of ethanol not on unit trains)

[173] http://www.reuters.com/article/2014/11/12/uk-railways-crude-bnsf-eases-congestion-idUSKCN0IW2D320141112

use a conservative cycle time and estimated that the utilization rate of 16.0 (or number of completed round trips annually), or 22.8 days in a cycle time would be appropriate. This is well above the average days that we have seen in our research and in our discussions with various stakeholders.

Assuming a utilization rate of 16.0 for HHFUTs, the rail industry would need:

- 52,755 tank cars to annually transport 844,076 carloads of crude traffic; and
- 12,311 tank cars to annually transport 196,977 carloads of ethanol.

PHMSA and FRA have kept the same utilization rate that RSI used for the non-unit trains. For crude traffic, which is in non-unit trains, the rail industry would need:

- 15,459 tank cars to transport 160,776 carloads of crude oil, assuming 10.4 average shipments per year, as RSI indicated. For ethanol traffic, which is in non-unit trains, the rail industry would need 17,689 tank cars to transport 222,122 carloads of ethanol, assuming 14.0 average shipments per year, as RSI indicated.

ECP Efficiencies

Certain business benefits were discussed and monetized in terms of labor cost savings in the NPRM's RIA. For instance, fewer brake tests were monetized in terms of labor time savings. PHMSA and FRA did not take into account a higher equipment utilization rate or increased capacity provided by unit trains operating in ECP brake mode. FRA regulations allow ECP-equipped trains to have a Class IA brake inspection every 3,500 miles, as opposed to every 1,000 or 1,500 miles required for other conventionally braked trains. This permits faster cycle times for ECP-equipped trains as each brake test generally takes about three hours, but in some cases can take up to eight hours to perform.

NS and BNSF currently operate under a pilot waiver an ECP-equipped unit coal train that permits brake inspections every 5,000 miles instead of the 3,500 miles permitted by 49 CFR § 232.607. If the safety data collected from this pilot waiver is positive, it is reasonable to assume that other railroads would apply to extend ECP brake inspections to every 5,000 miles as well. This could further increase the utilization rates of ECP brake operated unit trains.

The modern conventional air brake valves are fast-acting and sensitive. In cold weather, zero degrees Fahrenheit or below, the rubber seals between the air hoses of conventional brakes can shrink, creating excessive brake pipe leakage and higher air flow rates. As a result, braking response can be erratic from increased leakage in long trains during cold weather. To compensate, most railroads, including Class I railroads, operate shorter trains in this inclement weather to manage the excessive leakage and still be able to pass a Class I brake test. These trains can be shortened between 25-30 percent. Since ECP brakes do not depend on the modulation of brake pipe pressure to send the brake propagation signal, ECP brakes benefit and support safer operation of longer trains in cold weather conditions where brake pipe pressure is harder to maintain than on conventional brake systems. FRA assumes this would be common in very cold climates—like those in North Dakota—where a significant amount of the crude oil carloads originate. Railroads would benefit from using ECP brakes because they will be able to maintain normal train lengths, eliminating the need for addition tank cars and train sets.

ECP braking also improves the handling of longer trains. Maximum train length would become a function of available power (locomotives) and siding lengths. FRA has informally surveyed its regional staff to determine the average length of crude oil unit trains and found that a number of the unit trains contained 120 tank cars or more. For the purpose of this rule, a HHFUT is defined to be 70 tank cars or more in a consist. FRA believes that the rail industry will increase train length when operating in ECP brake mode. Increasing the average train length from 100 tank cars to 120 tank cars equates to a 17 percent reduction in the number of trains required to move the same number of carloads. This reduction of trains could enhance safety as there would be fewer derailments.

Under current FRA regulations, due to the real time equipment health monitoring requirements of AAR standard S-4200 in ECP-equipped locomotives, FRA regulations permit 95 percent operative brake operations at the initial terminal inspection of the train. This allows defective cars to be retained in the unit train until it reaches its destination and/or a prime repair location. The existing ECP regulations also permit defective equipment discovered en route to be hauled to the train's destination or a prime repair location before being repaired. Trains with conventional brakes are statutorily permitted to haul a car with defective brakes only to the nearest location where the necessary repairs can be made. This can result in long distance trains stopping several times while in transit to set-out defective equipment. Each of these stops can result in hours of delay. These delays are avoided by trains operating with ECP brake systems.

AAR currently specifies a 12.0 percent brake ratio; however, AAR allows trains using ECP brakes to increase the brake ratio to 14.0 percent. This increased brake ratio plus the addition of graduated release with ECP brakes will allow trains to keep an optimal speed because the locomotive engineer can ease into the brakes instead of applying and releasing full brakes under conventional braking.

PHMSA and FRA have reviewed reports and other research on the efficiency rate of ECP brakes. Stakeholders have discussed that that a reduction in equipment used can be seen between about 5 -15 percent. A Booz Allen Hamilton report[174] discussed that this topic. This report was relied on in FRA's 2008 ECP brake rule saying, "[t]his, in combination with the reduced wait time . . . has reduced cycle time experienced during ECP brake domestic initial implementation ranges from a low of 14 percent to a high of 33 percent."

[174] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology in the Railroad Industry,' Booz Allen Hamilton, August 2006, p. II-6.

In a BNSF analysis[175] of its coal operations, it was reported that it experienced a 5-10 percent reduction in its car fleet on trains equipped with ECP brakes. Another report[176] from 1999 noted that the Quebec Cartier Mining Company had seen an increase of 14 percent in the average tonnage per train compared to conventional trains with the same horsepower of locomotives. With ECP as the only contributing factor to improved efficiencies, this would translate to a 14 percent increase in cycle times, allowing them to have 14 percent few cars to provide the same service as was rendered. Even though the rail network is larger in the United States, these efficiencies would still be seen as they are based on cycle times.

In a public hearing[177] on October 19, 2007, Mike Iden, a general director for the Union Pacific Railroad, presented a graphic example of the potential efficiencies of ECP brakes. In this example he cited a UPS test train that traversed the country from New Jersey to California. In order to meet the schedule with conventional brakes, a special 75 mph speed limit was required. Mr. Iden pointed out that with the regulatory relief from inspections a minimum of two hours could be saved from each origin to destination. ECP would allow UPS to meet the same transportation time from origin to destination traveling at a 70 mph speed limit which would not only save fuel, but also reduce congestion caused by overtaking slower trains. He states in this hearing, "[m]y comments today will be focused not only on how ECP brake technology may impact the business of railroading but also on how ECP braking could be a positive factor for future railroad capacity."

On June 15, 2010, Jim Forrester, Manager Equipment Planning and Business Development for Norfolk Southern's Coal Business Group, presented a paper[178] to the National Coal Transportation Association to update it on NS's ECP brake pilot project. In this report he concluded that through direct testing comparing conventional trains and ECP-equipped trains (both would have dynamic braking) that ECP-equipped trains experienced a reduction in dwell time, ECP-equipped trains operated at track speed for longer periods of time, ECP-equipped trains were able to better control their speed, and ECP-equipped trains had faster loading processes and better car loading performances. On moderate grades, ECP-equipped trains stopped 33 percent faster and returned back to track speed 25 percent sooner. On heavy grades

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[175] Maryott, D. 2008. ECP Perspectives. Proceedings of the 100th Annual Convention and Technical Conference, pp.57-62 Chicago, IL: Air Brake Association

[176] McLaughlin, B. 1999 EP-60 ECP train Operation Data at Quebec Cartier Mining. Proceedings of the 91st Annual Convention and Technical Conference, Chart 2. Chicago, IL: Air Brake Association

[177] United States Department of Transportation, Federal Railroad Administration. Public Hearing on Electronically Controlled Pneumatic Brake Systems. October 19, 2007. Rosemont, Illinois.

[178] Forrester, J. 2010. Norfolk Southern ECP Brake Pilot Project Update. National Coal Transportation Association. Coeur d'Alene ID.

ECP-equipped trains stopped 50 percent faster and returned to track speed 97 percent sooner (as the hand brakes did not need to be applied to recharge the air brakes on the train).

Based upon this and other anecdotal evidence we determined that ECP brakes will deliver a 5-15 percent reduction of equipment used. For this analysis we used an improved utilization rate of eight percent for crude oil traffic instead of the high end of 15 percent. As the ethanol HHFUT are only 47 percent of the total ethanol fleet, PHMSA and FRA are estimating a smaller reduction to 5 percent.[179] Again, this percentage is appropriate as some studies have shown a much more significant reduction in the amount of equipment required. Using an eight percent reduction from the 52,755 tank cars required for crude service, ECP braked equipment would require only 48,535[180] cars to transport 884,076 car loads. A 5 percent reduction to the ethanol HHFUT fleet would permit 11,696[181] cars to transport 197,977 carloads annually. Multiplying the above tank car reduction estimates by the estimated cost of equipping a car with ECP results in an undiscounted cost savings of $36.9 million over 20 years.

In total PHMSA and FRA estimate that 4,835 fewer tank cars would need to be purchased over the 20 year period. The incremental cost difference between a CPC 1232 and a DOT-117 is $3,000. The total costs savings of ECP brakes are estimated to be $14.5 million.[182] PHMSA estimates that the reduction in demand for tank cars will be reflected by a reduction in the number of tank cars manufactured at the end of the time frame considered. Therefore, over a 20-year period the cost savings, discounted at 3 and 7 percent, are $12.1 million and $9.7 million respectively. These costs savings are discussed in further detail in Section 3. PHMSA and FRA did not use these tank car reduction estimates to reduce the number the number tank cars that would be retrofitted. Any impact of ECP in reducing the number of cars that would need to be built and purchased in the future is an additional benefit that is not monetized in this analysis.

[179] The amount of Crude oil shipped in unit trains is 84 percent. With only 47 percent of the fleet in unit train service you may lose some of the efficiencies. We used an improvement that was the lowest reported, which is 5 percent.

[180] 52,755 (tank cars for crude) *.08 (ECP efficiency reduction) = 4,220.38 (number of tank cars not need for service)

[181] 12,311 (tank cars for ethanol) *.05 (ECP efficiency reduction) = 615.55 (number of tank cars not need for service)

[182] 4,835 (fewer tank cars) * $3,000 (incremental cost difference) = $14,505,000

G. Braking Components

1. Status Quo

PHMSA expects all Class I and Class II railroads' HHFTs currently have two-way EOT devices or Distributed Power. PHMSA also expects all Class III railroads' HHFTs to either have EOT devices or operate over track with a maximum authorized speed of 30 mph.

2. End-of-Train Devices or Distributed Power, or 30 MPH in All Areas

This rule will require that every HHFT be equipped with a two-way EOT device or DP system, or would be required to travel at a speed no greater than 30 mph. With longer, heavier trains it is necessary to factor in train control issues. For all HHFT that are transporting less than 70 loaded tank cars of Class 3 flammable liquids, PHMSA and FRA believe that there would be no costs or benefits associated with this portion of the rule.

In most instances, existing FRA regulations require all Class I and Class II railroads transporting HHFTs to use two-way EOT devices or DP systems. See 49 CFR 232.407.

PHMSA and FRA therefore expect all Class III railroads that operate HHFTs on tracks with a maximum authorized speed in excess of 30 mph to operate using a two-way EOT device or DP. Class III railroads are likely to be equipped with two-way EOT devices when trains do not qualify for at least one of the exceptions to 49 CFR §232.407. Railroads operating over track with a maximum authorized speed of 30 mph or less would not be affected. PHMSA and FRA believe that codifying explicitly that all HHFT operating over 30-mph must use two-way EOT devices or DP systems will increase clarity for railroads. Therefore, PHMSA and FRA estimate no costs or benefits associated with braking for Class III railroads.

3. ECP Brakes on HHFUT

The final rule establishes a phase-in period for ECP brake systems, with the requirement that all HHFUTs, as previously defined, be equipped with and operate in ECP brake mode on January 1, 2021, when transporting one or more tank car load of a Packing Group I flammable liquid while traveling in excess of 30 mph. All other HHFUTs must be equipped with and operate in ECP brake mode on May 1, 2023. This schedule is based on feedback received during the comment period and estimates based on the new/retrofitted tank cars and new locomotive construction. PHMSA and FRA believe that this schedule supports installation of ECP brakes predominantly on new equipment. However, we expect that the phase-in period will likely be pushed forward as railroads gather ECP-equipped trains in advance of the deadline. The expectation is that railroads will have an incentive to put ECP-equipped trains in service, once acquired, to take advantage of the business benefits related to operating in ECP brake mode (e.g., reduced fuel consumption, longer inspection intervals).

For the purposes of this analysis, PHMSA and FRA are assuming that the construction of equipment with ECP brakes would begin in 2015. However, PHMSA and FRA believe that starting in 2017 enough tank cars would be available to begin making up a unit train meeting the

DOT-117 tank car specifications and operating with ECP brakes. PHMSA and FRA estimate that after the implementation date of May 1, 2023 the maximum number of unit trains on the general network at any given time would be 633 trains, as described in our ECP brake system forecast section.

Tank Car Costs for ECP Brakes

As previously discussed, PHMSA and FRA are using a weighted average estimate of $7,633 (the weighted average of $7,300 and $7,800 based on the assumption that around one third of the ECP-equipped fleet would be new construction and two thirds of the ECP-equipped fleet would be retrofits.[183] PHMSA and FRA estimated that 60,231 tank cars would be required to have ECP brakes. In accordance with the phase-in schedule, all HHFUT's would be equipped with ECP brakes by the May 1, 2023 deadline. The total cost to equip these tank cars with ECP would be $459.8 million. Discounted at 3 and 7 percent over a 20-year period costs are $409.8 and $354.7 million respectively.

Buffer cars are required for the transportation of these commodities by train. These buffer cars would need to work with ECP brakes. PHMSA and FRA believe that it is not cost beneficial to retrofit buffer cars with ECP brakes; however, PHMSA and FRA believe that each car would be equipped with cables that would connect the locomotives to the first tank car. This would allow the trains to operate in ECP brake mode. FRA's ECP braking systems regulations allow for only 95 percent of the train to be operating with ECP brakes, therefore; the buffer cars would not have to operate with ECP brakes. PHMSA and FRA estimate that the cables will cost $1,000 per buffer car and assume that two buffer cars per train will be used. In total, 1,266[184] buffer cars would be needed. The total cost of those additional buffer cars would be $1.3 million. Twenty-year discounted costs at 3 and 7 percent are $1.1 and $1.0 million, respectively.

PHMSA and FRA have included costs for various components, such as batteries and electrical cables, which would need to be replaced every five years. PHMSA and FRA believe these replacements would take place during a tank car's normal maintenance services. From comments received from the NPMR, PHMSA and FRA estimate that the batteries per tank car are $87 and that the cables that would be $300 per tank car. In this analysis, both of these components would need to be overhauled every five years, on each tank car. Over a twenty year period, the total cost of batteries and cable replacement is $64.7 million. Costs discounted at 3 and 7 percent over a 20 year period are $43.9 and $27.2 million, respectively.

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[183] [(1/3) (Fleet to be new construction) * $7,300 (cost of new construction)] + [(2/3) (Fleet to be retrofit) * $7,800 (cost of retrofit)] = $7,633

[184] 633 (estimated number of HHFUT at peak year) *2 (number of buffer cars required for each train) = 1,266 (buffer cars needed)

As earlier discussed, due to the efficiencies of ECP brakes, fewer tank cars will be needed to provide the same service. PHMSA and FRA estimate that 4,835 less tank cars would need to be purchased over the 20 year period. The incremental cost difference between a CPC 1232 and a DOT-117 is $3,000. The total costs savings of ECP brakes would be $14.5[185] million. PHMSA believes that these would be the last tank cars to be manufactured. Therefore, over a 20-year period the cost discounted at 3 and 7 percent, are $12.1 million and $9.7 million respectively.

Summary of Tank Car Costs for ECP Brakes

For the 20-year period of analysis, the estimated total cost related to ECP brakes on tank cars is $511.2 million. Total discounted costs are $442.7 million (3 percent) and $373.2 million (7 percent).

Locomotive Costs for ECP Brakes

As earlier discussed, PHMSA and FRA estimate that after the implementation date of May 1, 2023, the maximum number of unit trains on the general network at any given time would be 633 trains. Although the majority of these trains operate with three locomotives, PHMSA and FRA are estimating the cost to retrofit 2,532 locomotives, which would accommodate for out-of-service locomotives or any additional locomotives needed to operate the HHFUT's with ECP brakes. Class I Railroad's locomotive purchasing projections indicate that over 1,000 locomotives will be purchased in 2015. PHMSA and FRA believe that the railroads will continue this rate over next six to eight years, and the railroads would able allocate a portion of new locomotive purchases towards locomotives equipped with ECP brakes. The ECP brake add-on is estimated to cost $40,000 per locomotive. Over a 20-year period, the total cost to equip the locomotives with ECP brakes is $101.3 million. Discounted at 3 and 7 percent the costs are $89.5 and $76.5 million, respectively.

One of the major railroads currently operating an ECP-equipped subset of their fleet has purchased additional runaround cables used to bypass a locomotive that may not be equipped for ECP. These cables cost $1,000. PHMSA and FRA believe that other railroads would follow this business practice, and purchase one set for each locomotive in service. This would prevent any bottlenecks or slowdowns from occurring in the eventuality of an ECP-equipped locomotive that was not available. With these runaround cables, any locomotive not equipped with ECP brakes could be used as a non-controlling locomotive on the HHFUT, providing the required power to operate the train. PHMSA and FRA estimate it would cost $2.5 million to purchase these additional cables. Over a 20-year period, that total would be discounted to $2.2 million and $1.9 million using a 3 and a 7 percent discount rate.

[185] 4,835 (fewer tank cars) * $3,000 (incremental cost difference) = $14,505,000

For the 20-year period of analysis, the estimated total cost of ECP brakes on locomotives is $103.8 million. Discounted at 3 and 7 percent the total cost is $91.7 million and $78.4 million, respectively.

Asset Management for ECP Brakes

PHMSA and FRA acknowledge that initially an extra burden could be required to manage these assets associated with ECP braking systems. The railroads and shippers may currently have employees who already manage the crude oil and ethanol fleets. The additional cost would be attributed to determining the best way to manage these fleets in the first year of operation.[186] PHMSA and FRA estimate that an additional 8,000 labor-hours would be sufficient to manage all assists for the stakeholders involved. After the initial year of the management of these assets, further management would be included in the regular duties of the current asset managers. PHMSA and FRA assume the burdened hourly wage to be $62.30,[187] in 2016. The total cost of this burden would be $498,418. Discounted at 3 and 7 percent the total would be $469,807 and $435,338 respectively.

Summary of Locomotive Costs for ECP Brakes

For the 20-year period of analysis, the estimated total cost ECP brakes on locomotives is $104.3 million. Discounted values at 3 and 7 percent are $92.3 million and $79.9 million respectively.

Training Costs for ECP Brakes

PHMSA and FRA believe that there are two parts of the costs of training employees regarding ECP brakes. The first part is the training of the supervisors. These supervisors would then train the engineers, conductors, and carmen, which is the second part of the cost associated with training.

PHMSA and FRA looked the routes of the HHFUT's to determine how many crews could be affected. Using the waybill sample, FRA determined that approximately 68 percent of the total ton-miles were on routes that had crude or ethanol unit trains. PHMSA and FRA adjusted the

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[186] The first year we estimate the fleets would be operating with ECP is 2017; therefore, the cost to initially manage these fleets would take place in the prior year (i.e. 2016).

[187] PHMSA used the 2012 STB's Wage Statistics of Class I railroads to determine the number of Class I railroad employees who would be impacted by the proposed rule. Statement A-300 and the AAR Fact Book provided an employee count to assess the number of impacted railroad employee. PHMSA included all employees from Professional and Administrative and Transportation (Train and Engine). PHMSA incorporated a 75% overhead cost as well. These wages were adjusted in accordance with the "Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses." http://www.dot.gov/regulations/economic-values-used-in-analysis.

estimate to include 68 percent of the total crews, minus a small percentage of employees who are already trained in ECP. All training would be expected to take place during the first four years following the publication of the rule.

Locomotive Engineers and Conductor Supervisors

PHMSA and FRA estimate that seven training classes of supervisors, with a class size between 25 and 30, would take place at a centralized location for each of the railroads. The training would last two weeks and each of the trainers would require an additional 2 weeks to prepare for the training sessions.[188] PHMSA and FRA are using the burdened hourly wage rate of $61.89. The total cost for each trainer of locomotive engineers and conductors would be $54,459.[189] PHMSA and FRA assume that 200 locomotive engineer and conductor supervisors would travel to each of the railroad's centralized locations for this two-week training. The total cost of travel, hotel, food, and wages would be $7,148 per employee.[190] For 200 supervisors, the total cost would be approximately $1.4 million[191] which would take place in the first year of this analysis.

Carmen Supervisors

PHMSA and FRA estimate that seven training classes of carmen supervisors, with a class size between 25 and 30, would take place at a centralized location for each of the railroads. PHMSA and FRA estimate that the training would last two weeks, and that each of the trainers would require an additional two weeks to prepare for the training sessions.[192] PHMSA and FRA assume the burdened hourly wage rate to be $61.89. The total cost for the training of carmen supervisors would be $54,459.[193] PHMSA and FRA assume that 98 carmen supervisors would travel to each railroad's centralized location for this two week training. The total cost of travel,

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[188] As some of the railroads already operate with ECP brakes, only 4 railroads would have to develop new training programs.

[189] [$61.89 (Wage rate)*80 (Hours of training)*7 (Number of classes)]+[61.89 (Wage rate)*80(Hours to prepare for training)*4(Number of trainers)]=$54,459

[190] [12 (Days of the trip) * $100 (Daily hotel room cost)] + [315 (Average Cost of Flight)] + [12 (Days of the trip) * 46(Average per diem)] + [130 (Other transportation costs)] + [80 (Hours of training) * $61.89 (Wage rate)] = $7,147.80

[191] 200 (Number of supervisors) * 7,147.80 (Cost of training) = $1,429,560

[192] As stated earlier, some of the railroads already operate with ECP, therefore; only 4 railroads would have to develop new training programs.

[193] [$61.89 (Wage rate)*80 (Hours of training)*7 (Number of classes)]+[61.89 (Wage rate)*80(Hours to prepare for training)*4(Number of trainers)]=$54,459

hotel, food, and wages would is $7,148 per employee.[194] For 98 supervisors the total cost would be $700,485,[195] which would take place in the first year of this analysis.

The second part of the training would be to train the locomotive engineers, conductors, and carmen on how to use, inspect, and maintain the ECP brakes.

PHMSA and FRA looked at the routes of the HHFUT's to determine how many crews could be affected. Using the waybill sample, FRA determined that approximately 68 percent of the total ton-miles were on routes that had crude oil or ethanol unit trains. PHMSA and FRA adjusted the estimate to include 68 percent of the total crews. Based on these assumptions, around 18,000 engineers, 27,000 conductors, and 6,500 carmen would receive additional training.[196] An adjustment to the duration of training was also done upon recommendations of the FRA's ECP brake specialists. In the NPRM we estimated that it would take two weeks to train the locomotive engineers. We believe that a more accurate estimate is two days. We also estimated in the NPRM it would take two days to train the conductors. This estimate was reduced to one day.

Locomotive Engineers

PHMSA and FRA believe that the locomotive engineer training classes would take place at the local sites in classrooms of 30 employees. These classes would be taught by the supervisors who were trained as described in the previous section. With approximately 18,000 locomotive engineers, there would be around 597 classes taught. Training classes are expected to last two days, including a day of on-the-job training. The costs associated with the supervisors to train the locomotive engineers would be $599,307.[197] This would ensure that all locomotive engineers are trained to confirm safe operations of the trains. The cost to train all the locomotive engineers would be $14.7 million.[198]

Conductors

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[194] [12 (Days of the trip) * $100 (Daily hotel room cost)] + [315 (Average Cost of Flight)] + [12 (Days of the trip) * 46(Average per diem)] + [130 (Other transportation costs)] + [80 (Hours of training) * $61.89 (Wage rate)] = $7,147.80

[195] 98 (Number of supervisors) * 7,147.80 (Cost of training) = $770,485

[196] An additional 2 percent of locomotive engineers, conductors, and carmen were not included as PHMSA believes that these employees already operate with ECP-equipped trains, and therefore have received the proper training.

[197] 597 (Number of classes) * 16 (Hours of training) * $61.89 (Wage rate) = $591,173. This cost increases to $599,307 as the classes are spread over a three year period, and wage rates increase each year.

[198] 17,914 (Number of engineers) *16 (Hours of training) * $50.56 (Wage Rate) = $14,491,709. This cost increases to $14,687,760 as the classes are spread over a three year period, and wage rates increase each year.

PHMSA and FRA estimate that there are 27,070 conductors who would also need to be trained. Similar to the previously described locomotive engineer training sessions, these would take place at the local sites in classes of 30 employees. These classes would be taught by the supervisors who are already trained. There would be approximately 902 classes taught with over 27,000 conductors. Training classes are estimated to last one day. The costs associated with conductor supervisory trainers would be $452,798.[199] 27,070 conductors would need to be trained in order to ensure safe operations of the trains. The cost to train these conductors would be $11.1 million.[200]

Carmen

PHMSA and FRA estimate that there are 6,500 carmen who would also need to be trained.[201] Similar to the previous sessions, these would take place at the local sites in classes of 30 employees. These classes would be taught by the supervisors who were trained as described in the previous section. With an estimated 6,500 carmen to be trained, there would be approximately 217 classes taught. PHMSA and FRA estimate that these training classes would last six days, including on the job training. The costs associated with the supervisors to train the carmen would be $761,117.[202] All affected carmen would need to be trained in order to ensure safe operations of the trains. The cost to train these carmen would be $18.7 million.[203]

Summary of Training Costs for ECP Brakes

For the 20-year period of analysis, the estimated total training costs for ECP brakes is $48.5 million. Discounted at 3 and 7 percent, the total cost values are $44.5 million and $39.9 million respectively. PHMSA and FRA assume that any additional future training required for ECP

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[199] 902 (Number of classes) * 8 (Hours of training) * $61.89 (Wage rate) = $446,598. This cost increases to $452,798 as the classes are spread over a three year period, and wage rates increase each year.

[200] 27,070 (Number of conductors) *8 (Hours of Training) * $50.56 (Wage Rate) = $10,949,273.60 This cost increases to $11,097,124 as the classes are spread over a five year period, and wage rates increase each year.

[201] An additional 5 percent of carmen were not included as PHMSA believes that these employees already operate with ECP trains and therefore have received the proper training.

[202] 217 (Number of classes) * 56 (Hours of training) * $61.89 (Wage rate) = $752,087. This cost increases to $761,117 as the classes are spread over a three year period, and wage rates increase each year.

[203] 6,500 (Number of conductors) *56 (Hours of Training) * $50.56 (Wage Rate) = $18,403,840. This cost increases to $18,653,396 as the classes are spread over a five year period, and wage rates increase each year.

would be tied into the current refresher training programs and would therefore have minimal additional costs.

Summary of Costs

For the 20-year period of analysis, the estimated total cost for ECP brakes is $664.0 million. Discounted values at 3 and 7 percent are $579.4 million and $492.0 million respectively.

Phase-in

In analyzing the NPRM, PHMSA and FRA assumed that all train related benefits will accrue at 100 percent once brakes have been installed on all HHFTs by year 2018 and thereafter. PHMSA and FRA also assumed that one-third of the HHFT fleet will be equipped with ECP brakes in 2016, two-thirds in 2017, and all of the fleet in 2018 and subsequent years.

In this final rule analysis, PHMSA and FRA assume that benefits will accrue the year after ECP brakes are installed on a tank car for an HHFUT, and that 20 percent of the cars used in crude oil unit trains will be equipped with ECP brakes each year starting in 2016, until all cars are equipped by the end of 2020. Thus, the benefits from operations involving ECP brakes on crude oil unit trains will start at 20 percent of the full performance level in 2017, rising to the full performance level at the beginning of 2021. Ethanol unit trains will need to be equipped with ECP brakes by May 1, 2023. In this final rule analysis PHMSA and FRA assume that 15 percent of the cars used in ethanol unit trains will be equipped with ECP brakes each year from 2016 through 2020, and that 10 percent of the cars used in unit trains will be equipped with ECP brakes in each of the years 2021 and 2022, and the last 5 percent of cars used in ethanol unit trains will be equipped in the first four months of 2023. Thus, the benefits from operations involving ECP brakes on crude oil unit trains will start at 15 percent of the full performance level in 2017, rising to the full performance level at the beginning of 2024.

Table BR6: Phase-In

	Benefit Percentage (%)	
Year	**Crude Oil Unit Trains**	**Ethanol Unit Trains**
2015	0%	0%
2016	0%	0%
2017	20%	15%
2018	40%	30%
2019	60%	45%
2020	80%	60%
2021	100%	75%
2022	100%	85%
2023	100%	95%
2024	100%	100%

Safety Benefits of ECP Brakes (Other Than Accident Avoidance)

The potential violence and destruction of a HHFUT accident is substantial. ECP brakes would help to mitigate the magnitude of many of the horrific accidents we have seen over the last decade. When looking at the mitigation or avoidance of these incidents, it is important to understand how long it can take to apply the brakes. What ECP brakes do is replace the air pressure controlled valves, which are used on conventional triple valves, and substitute them with electronically controlled valves. This allows the response time for braking to occur essentially at the speed of light, instead of the speed of sound. Research shows that the quicker and more uniform braking from ECP brakes can reduce the stopping distance of a train from 40 to 60 percent. Brake shoe wear can also be reduced by 20 to 25 percent.[204] As a result, ECP brakes would reduce the damages associated with HHFUT accidents. Safety benefits include both reductions in property damage caused as well as the number of fatalities and/or injuries.

The survivability of tank cars can be improved by decreasing the force of the impacts experienced in a derailment. This can be accomplished by reducing the energy of the train as quickly as possible through reduced speeds and/or faster and uniform braking. ECP brakes result in substantially greater reductions in kinetic energy than EOT or DP brake systems. PHMSA and FRA have data on the estimated effectiveness rates for ECP brakes at 30, 40, and 50 mph. In estimating what the safety benefits would be PHSMA and FRA took a weighted average of those results, weighting by severity using the quantity released in the historical record. By assigning historical derailments under 35 mph to the 30 mph effectiveness rate, assigning derailments between 35 and 45 mph to the 40 mph effectiveness rate, and assigning derailments over 45 mph to the 50 mph effectiveness rate we were able to produce a weighted average effectiveness rate. Our modeling and simulations indicate that 19.7 percent fewer tank cars would puncture if a HHFUT derailment were to occur involving a train set with ECP brakes relative to a train set operating with a two-way-EOT or DP in the rear (see table BR4). PHMSA and FRA used this effectiveness rate of 19.7 percent to estimate the benefits that would result from deployment of ECP braking on HHFUT.

[204] George Bibel, *Train Wreck: The Forensics of Rail Disasters* (Baltimore, Maryland: The John Hopkins University Press, 2012), page 251.

Table BR7: Effectiveness Rate of ECP Brakes Weighted by Volume of Product Spilled in a Derailment					
	Number of Incidents	Total Spill Volume	Share of Total Volume	ECP Effectiveness Rate at 30, 40, 50 mph	Cumulative Effectiveness Rate
Below 34 mph	33	798,433	22.8%	20.10%	4.6%
35-44 mph	8	1,488,350	49.2%	25.80%	12.7%
45 mph and above	5	980,180	28%	8.60%	2.4%
Total	46	3,499,656	100%		19.7%

To derive benefits, the estimated incident damages in the absence of this rule are multiplied by the percentage of cars equipped with ECP brakes in each year and by the effectiveness of ECP braking, which as noted is 19.7 percent. We have also broken out the percentage of crude oil traffic and ethanol traffic that would be transported on HHFUT.

As explained in more detail in section VII of this analysis, "*Estimation of Expected Benefits*" there are expected benefits for low consequence events (LCE), and for high consequence events (HCE). The LCE are an estimation of the number of HHFT accidents involving flammable liquids in absence of the final rule and an estimation of the expected damages from accidents extrapolated from the existing United States hazardous materials accident records. The LCE events look at the projected damages that might occur if the rate and size of future accidents were similar to the existing United States safety record. In addition to these projected accidents, there might be one or more higher-consequence events. The HCE are an estimation of how many of these higher-consequence events might occur in absence of the final rule and an estimation of expected damages from those higher-consequence events.

ECP brakes will gradually be implemented over approximately eight years, as the rule mandates a date of May 1, 2023.[205] One third of the tanks cars that will be equipped with ECP brakes will be the new construction tank cars. This will maximize the value of the return on investment. Table BR8 and BR9 show the benefits[206] by year for HHFUT transporting crude oil for LCE and HCE, while Tables BR10 and BR11 show the benefits by year for ethanol.

[205] There is a January 1, 2021, deadline for HHFUTs transporting one or more tank car load of a Packing Group I flammable liquid while traveling in excess of 30 mph. All other HHFUTs must meet the deadline of May 1, 2023.

[206] Total Damages for LCE and HCE are described in detail in the Benefits Section of this document.

Table **BR8**: Total LCE ECP Benefits for Crude Oil Traffic by Year

Year	Total Damages	Percentage of Crude HHFUT of Total Carloads	Percent of Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 179,915,412	54.3%	0%	19.7%	$ -	$ -	$ -
2016	$ 176,427,442	54.3%	0%	19.7%	$ -	$ -	$ -
2017	$ 182,777,809	54.9%	20%	19.7%	$ 3,955,803	$ 3,229,114	$ 3,620,120
2018	$ 196,334,749	56.8%	40%	19.7%	$ 8,785,860	$ 6,702,690	$ 7,806,123
2019	$ 208,471,811	58.3%	60%	19.7%	$ 14,359,423	$ 10,238,070	$ 12,386,565
2020	$ 221,509,522	59.6%	80%	19.7%	$ 20,800,121	$ 13,859,999	$ 17,419,774
2021	$ 222,699,151	59.6%	100%	19.7%	$ 26,143,997	$ 16,281,167	$ 21,257,462
2022	$ 223,063,891	59.2%	100%	19.7%	$ 26,006,132	$ 15,135,806	$ 20,529,481
2023	$ 208,678,220	59.2%	100%	19.7%	$ 24,335,284	$ 13,236,782	$ 18,650,969
2024	$ 223,774,639	59.2%	100%	19.7%	$ 26,117,072	$ 13,276,595	$ 19,433,554
2025	$ 223,247,669	59.2%	100%	19.7%	$ 26,030,711	$ 12,367,003	$ 18,805,139
2026	$ 219,084,383	58.7%	100%	19.7%	$ 25,340,467	$ 11,251,470	$ 17,773,294
2027	$ 201,212,338	58.3%	100%	19.7%	$ 23,109,493	$ 9,589,618	$ 15,736,440
2028	$ 212,100,606	57.9%	100%	19.7%	$ 24,175,297	$ 9,375,597	$ 15,982,719
2029	$ 208,330,088	57.4%	100%	19.7%	$ 23,555,277	$ 8,537,516	$ 15,119,236
2030	$ 204,293,980	56.9%	100%	19.7%	$ 22,883,191	$ 7,751,329	$ 14,260,048
2031	$ 200,686,778	56.4%	100%	19.7%	$ 22,285,382	$ 7,054,981	$ 13,483,023
2032	$ 196,924,311	55.9%	100%	19.7%	$ 21,668,654	$ 6,410,973	$ 12,728,051
2033	$ 193,606,475	55.4%	100%	19.7%	$ 21,116,256	$ 5,838,821	$ 12,042,306
2034	$ 190,456,652	54.8%	100%	19.7%	$ 20,579,575	$ 5,318,153	$ 11,394,412
				Total	**$ 381,247,995**	**$ 175,455,685**	**$ 268,428,715**

Table **BR9**: Total HCE ECP Benefits for Crude Oil Traffic by Year

Year	Total Damages	Percentage of Crude HHFUT of Total Carloads	Percent of Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 140,250,000	54.3%	0%	19.7%	$ -	$ -	$ -
2016	$ 140,250,000	54.3%	0%	19.7%	$ -	$ -	$ -
2017	$ 140,250,000	54.9%	20%	19.7%	$ 3,035,387	$ 2,477,780	$ 2,777,809
2018	$ 140,250,000	56.8%	40%	19.7%	$ 6,276,102	$ 4,788,008	$ 5,576,235
2019	$ 140,250,000	58.3%	60%	19.7%	$ 9,660,343	$ 6,887,691	$ 8,333,096
2020	$ 140,250,000	59.6%	80%	19.7%	$ 13,169,714	$ 8,775,536	$ 11,029,428
2021	$ 140,250,000	59.6%	100%	19.7%	$ 16,464,793	$ 10,253,446	$ 13,387,384
2022	$ 140,250,000	59.2%	100%	19.7%	$ 16,351,190	$ 9,516,541	$ 12,907,780
2023	$ 140,250,000	59.2%	100%	19.7%	$ 16,355,438	$ 8,896,274	$ 12,535,081
2024	$ 140,250,000	59.2%	100%	19.7%	$ 16,368,787	$ 8,321,061	$ 12,179,915
2025	$ 140,250,000	59.2%	100%	19.7%	$ 16,353,171	$ 7,769,274	$ 11,813,878
2026	$ 140,250,000	58.7%	100%	19.7%	$ 16,222,062	$ 7,202,790	$ 11,377,828
2027	$ 140,250,000	58.3%	100%	19.7%	$ 16,107,891	$ 6,684,202	$ 10,968,690
2028	$ 140,250,000	57.9%	100%	19.7%	$ 15,985,741	$ 6,199,546	$ 10,568,458
2029	$ 140,250,000	57.4%	100%	19.7%	$ 15,857,660	$ 5,747,546	$ 10,178,428
2030	$ 140,250,000	56.9%	100%	19.7%	$ 15,709,555	$ 5,321,370	$ 9,789,675
2031	$ 140,250,000	56.4%	100%	19.7%	$ 15,574,144	$ 4,930,375	$ 9,422,613
2032	$ 140,250,000	55.9%	100%	19.7%	$ 15,432,471	$ 4,565,911	$ 9,064,950
2033	$ 140,250,000	55.4%	100%	19.7%	$ 15,296,776	$ 4,229,686	$ 8,723,538
2034	$ 140,250,000	54.8%	100%	19.7%	$ 15,154,553	$ 3,916,224	$ 8,390,708
				Total	**$ 255,375,776**	**$ 116,483,261**	**$ 179,025,496**

Table BR10: Total LCE ECP Benefits for Ethanol Traffic by Year

Year	Total Damages	Percentage of Ethanol HHFUT of Total Carloads	Percent Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 179,915,412	16.6%	0%	19.7%	$ -	$ -	$ -
2016	$ 176,427,442	16.6%	0%	19.7%	$ -	$ -	$ -
2017	$ 182,777,809	16.3%	15%	19.7%	$ 878,485	$ 717,105	$ 803,938
2018	$ 196,334,749	15.2%	30%	19.7%	$ 1,766,667	$ 1,347,782	$ 1,569,661
2019	$ 208,471,811	14.4%	45%	19.7%	$ 2,660,253	$ 1,896,723	$ 2,294,757
2020	$ 221,509,522	13.7%	60%	19.7%	$ 3,577,118	$ 2,383,585	$ 2,995,780
2021	$ 222,699,151	13.7%	75%	19.7%	$ 4,493,644	$ 2,798,416	$ 3,653,744
2022	$ 223,063,891	13.9%	85%	19.7%	$ 5,187,070	$ 3,018,922	$ 4,094,721
2023	$ 208,678,220	13.9%	95%	19.7%	$ 5,420,078	$ 2,948,163	$ 4,154,039
2024	$ 223,774,639	13.9%	100%	19.7%	$ 6,106,170	$ 3,104,067	$ 4,543,564
2025	$ 223,247,669	13.9%	100%	19.7%	$ 6,105,699	$ 2,900,774	$ 4,410,887
2026	$ 219,084,383	14.1%	100%	19.7%	$ 6,106,429	$ 2,711,327	$ 4,282,926
2027	$ 201,212,338	14.4%	100%	19.7%	$ 5,699,939	$ 2,365,272	$ 3,881,381
2028	$ 212,100,606	14.6%	100%	19.7%	$ 6,111,741	$ 2,370,239	$ 4,040,581
2029	$ 208,330,088	14.9%	100%	19.7%	$ 6,109,545	$ 2,214,380	$ 3,921,484
2030	$ 204,293,980	15.2%	100%	19.7%	$ 6,111,889	$ 2,070,308	$ 3,808,727
2031	$ 200,686,778	15.5%	100%	19.7%	$ 6,112,387	$ 1,935,025	$ 3,698,095
2032	$ 196,924,311	15.7%	100%	19.7%	$ 6,109,094	$ 1,807,460	$ 3,588,449
2033	$ 193,606,475	16.0%	100%	19.7%	$ 6,110,975	$ 1,689,736	$ 3,485,004
2034	$ 190,456,652	16.3%	100%	19.7%	$ 6,119,619	$ 1,581,426	$ 3,388,285
				Total	**$ 90,786,803**	**$ 39,860,711**	**$ 62,616,023**

Table BR11: Total HCE ECP Benefits for Ethanol Traffic by Year

Year	Total Damages	Percentage of Ethanol HHFUT of Total Carloads	Percent Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 140,250,000	16.6%	0%	19.7%	$ -	$ -	$ -
2016	$ 140,250,000	16.6%	0%	19.7%	$ -	$ -	$ -
2017	$ 140,250,000	16.3%	15%	19.7%	$ 674,084	$ 550,253	$ 616,882
2018	$ 140,250,000	15.2%	30%	19.7%	$ 1,262,003	$ 962,776	$ 1,121,273
2019	$ 140,250,000	14.4%	45%	19.7%	$ 1,789,693	$ 1,276,026	$ 1,543,805
2020	$ 140,250,000	13.7%	60%	19.7%	$ 2,264,872	$ 1,509,180	$ 1,896,795
2021	$ 140,250,000	13.7%	75%	19.7%	$ 2,829,978	$ 1,762,368	$ 2,301,031
2022	$ 140,250,000	13.9%	85%	19.7%	$ 3,261,337	$ 1,898,128	$ 2,574,530
2023	$ 140,250,000	13.9%	95%	19.7%	$ 3,642,766	$ 1,981,423	$ 2,791,877
2024	$ 140,250,000	13.9%	100%	19.7%	$ 3,827,022	$ 1,945,464	$ 2,847,663
2025	$ 140,250,000	13.9%	100%	19.7%	$ 3,835,759	$ 1,822,342	$ 2,771,034
2026	$ 140,250,000	14.1%	100%	19.7%	$ 3,909,118	$ 1,735,695	$ 2,741,776
2027	$ 140,250,000	14.4%	100%	19.7%	$ 3,972,999	$ 1,648,653	$ 2,705,419
2028	$ 140,250,000	14.6%	100%	19.7%	$ 4,041,345	$ 1,567,303	$ 2,671,805
2029	$ 140,250,000	14.9%	100%	19.7%	$ 4,113,009	$ 1,490,744	$ 2,639,984
2030	$ 140,250,000	15.2%	100%	19.7%	$ 4,195,877	$ 1,421,289	$ 2,614,732
2031	$ 140,250,000	15.5%	100%	19.7%	$ 4,271,643	$ 1,352,293	$ 2,584,414
2032	$ 140,250,000	15.7%	100%	19.7%	$ 4,350,912	$ 1,287,278	$ 2,555,703
2033	$ 140,250,000	16.0%	100%	19.7%	$ 4,426,837	$ 1,224,057	$ 2,524,563
2034	$ 140,250,000	16.3%	100%	19.7%	$ 4,506,414	$ 1,164,543	$ 2,495,092
				Total	**$ 61,175,668**	**$ 26,599,815**	**$ 41,998,379**

The safety benefits (excluding accident prevention benefits) of ECP will range from $472.0 million to $788.6 million; discounted at 7 percent, the range is $215.3 million to $358.4 million and discounted at 3 percent, the range is $331.0 million to 552.1 million.

Accident Prevention Benefits Related to ECP Brakes

FRA evaluated derailments that occurred over the last twenty years which may have been avoidable if a train was operating with ECP brakes. FRA specifically looked for derailments (accident types) in which train handling was the cause of the incident. FRA also looked for the term "emergency" to be in the narrative of the accident/incident reports in order to find trains that went into emergency mode while operating.

FRA identified 478 accident/incident records in which a train incident may have occurred due to train handling. The focus was on cause codes (such as human factor or mechanical) where ECP brakes would have avoided or reduced the consequences of a derailment. After reviewing the records, FRA removed duplicate events, non-train handling events and events that occurred off of main track, FRA identified 252 incidents as candidates for ECP brake accident avoidance benefits.

FRA also identified 86 accident/incident records in which a train incident may have occurred due to string lining.[207] As above, FRA removed duplicate events and events that occurred off of main track. FRA identified 44 incidents as candidates for measuring ECP brake accident avoidance benefits.

FRA technical experts reviewed the records using professional judgment to determine how likely a train accident could have been avoided. These incidents were categorized as "LIKELY," "UNLIKELY," and "NOT SURE." FRA assigned effectiveness rates of 90 percent, 0 percent, and 50 percent respectively to each of these incidents.

FRA reviewed the damages to equipment associated with these incidents. Since the commodities carried were generally not hazardous materials, it is reasonable to assume that this represents the lower bound of the consequences that could be prevented with ECP brakes. The total unadjusted values from these reports showed that damages over the 20-year period amounted to $44.8 million. While PHMSA and FRA elsewhere in this analysis estimate the cost of a derailment based on the cost per gallon of crude or ethanol spilled, it is more appropriate here to use the accident/incident report estimate because these accidents primarily occurred when a train was pulling a light load (often, a train that has a large number of empty or residue cars). Therefore, damages were predominantly to equipment (excluding injuries and fatalities), and this category of damage is accurately captured in the accident/incident reports.

There was one fatality and five injuries in four of these accidents. FRA reviewed the F 6180.54 form (accident/incident reports) and read the narratives of each of these events. FRA also looked at the F 6180.55A reports which indicated the type and severity of these injures. FRA then made

[207] String lining occurs when the brakes are applied and the train is on a curve. The pulling motion from the back and the front of the train can cause the cars to derail inside the curve.

its best judgment in putting them into one of the five categories of the AIS (Abbreviated Injury Scale). FRA has no rail-type injury standard/average, as it tries to be as specific as possible.

FRA applied DOT's 2014 "Guidance on Treatment of the Economic Value of a Statistical Life in United States Department of Transportation Analyses." This policy updated the value of a statistical life (VSL) to $9.2 million in 2014 and revised guidance used to compute benefits based on AIS injury and fatality avoidance in each year of the analysis based on forecasts from the Congressional Budget Office (CBO) of a 1.18 percent annual growth rate in median real wages over the next 30 years (2014–2044). The total damage for injuries and fatalities over the twenty-year period was $12.6 million.

The impact on unit trains covered by the requirement was estimated by determining the number of locomotives that would be implemented with ECP brakes. There are approximately 25,500 locomotives in the current fleet. FRA estimated that at the peak year, 2024, of the next 20-year period, a total of 633 unit trains for both crude oil and ethanol would be on the network at any given time. With each unit train requiring three or more locomotives and extra locomotives required to cover for when a locomotive is out-of-service, FRA estimated that 1,899 locomotives equipped with ECP brakes would be required. This would account for 7.4 percent of the total locomotive fleet.

Incidents were categorized into three likelihood categories. FRA assigned the appropriate effectiveness rate to each incident. For the purposes of this analysis, FRA looked at the 7.4 percent effectiveness. FRA took 7.4 percent as this will focus on the locomotive fleet that would be identified for crude oil or ethanol unit train traffic. FRA determined that the annual property damages would be $78,812 and the injury prevention would also be $40,635. Full benefits of the avoidable incidents for ECP brake trains would be staggered over a six year period. Over a twenty year period, FRA believes that the total benefits of ECP accident avoidance would be $1.9 million, discounted at 7 percent and 3 percent the totals would be $0.8 million and $1.3 million, respectively. Given that property damage estimates for the 20-year accident pool were not updated and the likelihood for omission of relevant accidents without a narrative including the terms searched for, estimated accident avoidance benefits are understated.

Business Benefits of ECP Braking

ECP braking systems also have additional potential operational benefits. In 2008, FRA issued a final rule permitting the use of ECP brake systems. In an accompanying analysis,[208] FRA found that ECP brakes offered major benefits in train handling, car maintenance, fuel savings, and

[208] Electronically Controlled Pneumatic Brake Systems, Final Rulemaking. Regulatory Analysis, Federal Railroad Administration, June 2008, Docket ID: FRA-2006-26175-0065, www.regulations.gov

increased capacity under the operating conditions present in that timeframe. ECP brake use could also significantly enhance rail safety in ways beyond reducing the severity of derailments.

Compared with the potential performance of ECP brakes, conventional braking systems contribute to greater in-train forces, more complex train handling, longer stopping distances, and safety risks of prematurely depleting air brake reservoirs. Traditional train-handling procedures require anticipating draft (pulling) and buff (compressive) forces within the train, particularly on hilly terrain; and any misstep can result in derailment. Conventional brakes can also stop functioning on individual cars en route without the locomotive engineer being aware of it. These challenges and concerns are greatly reduced in the ECP brake mode of operation, during which all cars brake simultaneously by way of an electronic signal. ECP brake systems simultaneously apply and release freight car air brakes through a hardwired electronic pathway down the length of the train, and allow the engineer to "back off" or reduce the braking effort to match the track grade and curvature, without having to completely release the brakes and having to recharge the main reservoirs before another brake application can be made.

These differences in the operation of the two braking systems give ECP brakes several business benefits. Operationally, ECP brakes have the potential to save fuel and reduce emissions, reduce wear and stress on wheels and brake shoes, and provide train engineers greater control on the braking characteristics of trains. From a safety perspective, ECP brakes greatly reduce the risk of runaway trains due to a diminished reservoir air supply, and reduce the probability of an incident by providing 40 to 60 percent shorter stopping distances. ECP brake wiring also provides the train a platform for the gradual addition of other train-performance monitoring devices using sensor-based technology to maintain a continuous feedback loop on the train's condition for the train crew.

The safety benefits of ECP brakes are included in the general benefits analyzed and accounted for above. The 2008 FRA analysis accounted for four categories of benefits (three categories of safety benefits and one category of business benefits). The safety benefits included reductions in costs of highway-rail grade crossing accidents, reductions in costs of train and equipment accidents, and reductions in environmental and clean-up costs. Those benefits are already accounted for as best as possible, given the available information. The present analysis above does not, however, account for business benefits.

Of the business benefits identified in the 2008 analysis, PHMSA and FRA are including in this analysis a subset of those benefits, adjusted as shown in tables below. The benefits are adjusted for differences in application and scale, differences in cost levels, and differences in fuel efficiency.

Flow Assumptions

In the NPRM, PHMSA and FRA assumed there would be 900 locomotives (three each in 300 sets), 100 trailing cars behind each set of locomotives, and that each train will travel an average of 220 miles per day. This resulted in an estimate of 23,760,000 unit train miles per year (assuming each unit train, and thus every unit train car, travels 360 days/year), which using 100 cars per train, implied 2,376,000,000 unit train car miles per year.

In this final rule analysis, PHMSA and FRA forecast that much greater numbers of carloads of crude oil will be shipped, with 84 percent hauled by unit trains, and an average length of haul by crude oil unit trains of 1,000 miles. This is a reduced estimate of length of haul from the analysis of the NPRM, and reflects a reexamination of the original data that showed some shipments included in the estimate used in analyzing the NPRM included mileage in Canada. For example, in the table below PHMSA and FRA are forecasting that there will be 761,028 crude oil car loads in 2017. PHMSA and FRA multiply 761,028 car loads times 1,000 miles, times 2 for the train making a round trip, times 84 percent to arrive at an estimate of 1,278,527,006 crude oil carload miles in unit trains in 2017. It should be noted that the business benefits are not dependent on whether tank cars are new construction, or retrofitted, nor dependent on shell characteristics, as long as the cars used in unit trains are equipped with ECP brakes and the brakes are functioning.

Also, in this final rule analysis, PHMSA and FRA assume that 47 percent of ethanol car loads will be hauled in unit trains. PHMSA and FRA further assume that the average length of haul for an ethanol unit train will be 1,300 miles. For example, in the table below PHMSA and FRA are forecasting that there will be 402,736 ethanol car loads in 2017. PHMSA and FRA multiply 402,736 car loads times 1,300 miles, times 2 for the train making a round trip, times 47 percent to arrive at an estimate of 492,143,392 ethanol carload miles in unit trains in 2017. PHMSA and FRA then add the 1,278,527,006 crude oil carload miles plus the 492,143,392 ethanol carload miles, to arrive an estimated 1,770,670,398 total affected carload miles in 2017.

Table BR12- HHFUT Car Miles

Year	Crude Car Loads	Crude Unit Car Miles	Ethanol Car Loads	Ethanol Unit Car Miles	Unit Car Miles
2014	569,387	956,570,244	387,665	473,726,630	1,430,296,874
2015	723,699	1,215,813,967	394,977	482,661,894	1,698,475,861
2016	726,742	1,220,926,207	396,882	484,989,804	1,705,916,011
2017	761,028	1,278,527,006	402,736	492,143,392	1,770,670,398
2018	844,901	1,419,433,277	404,852	494,729,144	1,914,162,421
2019	920,347	1,546,182,288	406,310	496,510,820	2,042,693,108
2020	999,596	1,679,320,776	409,649	500,591,078	2,179,911,854
2021	1,004,852	1,688,151,377	411,575	502,944,650	2,191,096,027
2022	999,277	1,678,785,730	419,078	512,113,316	2,190,899,046
2023	999,486	1,679,136,110	418,797	511,769,934	2,190,906,044
2024	1,002,977	1,685,000,570	419,099	512,138,978	2,197,139,548
2025	999,375	1,678,949,244	418,947	511,953,234	2,190,902,478
2026	972,594	1,633,957,147	418,876	511,866,472	2,145,823,619
2027	950,327	1,596,549,007	418,923	511,923,906	2,108,472,913
2028	927,328	1,557,910,570	418,994	512,010,668	2,069,921,238

2029	903,274	1,517,500,589	418,718	511,673,396	2,029,173,985
2030	877,236	1,473,756,900	418,752	511,714,944	1,985,471,844
2031	854,058	1,434,816,902	418,658	511,600,076	1,946,416,978
2032	830,166	1,394,678,040	418,303	511,166,266	1,905,844,306
2033	808,749	1,358,698,639	418,301	511,163,822	1,869,862,461
2034	787,945	1,323,747,180	418,760	511,724,720	1,835,471,900

Set Out Relief

The set out relief from the 2008 rule only affects trains equipped with ECP brakes. Since the final rule requires ECP brakes, equipped trains will realize the potential benefits permitted by the 2008 rule, which allowed, but did not require ECP brakes. Under the 2008 rule, trains equipped with ECP brakes were given relief from set-out requirements. The benefit of set-out relief was described the analysis:[209]

"Additional regulatory flexibility is provided by the rule. The removal of equipment with defective or inoperative brakes en route, known as set-outs, is eliminated. The defective equipment is permitted to remain in the train consist to destination, not to exceed 3,500 miles. ECP brake systems monitor in real time the health of the train's brake system, thus eliminating the safety concern that exists in conventionally-braked trains. Locomotive engineers operating trains equipped with ECP brakes have the ability to monitor the condition and the location of defective or inoperable brakes. ECP brake-equipped trains are not required to stop and set out a defective car. FRA requested and received comments and information on the cost per set-out. The AAR provided comments on the cost per set-out ($400) and the quantity of set-outs (10 percent). While FRA agrees that the original set-out percentage was high, the 10 percent long-haul train figure offered by AAR is too low. This figure does not address the extended mileage that the rule permits ECP brake trains to travel (3,500 miles versus 1,000 miles). FRA estimates, on average, 20 percent of trains must stop en route for one set-out due to the increased length of haul of ECP brake trains. FRA accepts the $400 figure provided by the AAR for the cost of a set-out. The number of ECP brake-equipped trains annually, as estimated above, is 178,071 + 14,000 unit trains = 192,071 trains per year. Approximately, half of these trains will likely avoid one set-out valued at $400 each."

For purposes of this analysis, there is no reason to increase the value of avoided set-outs from 10 percent to 20 percent, because only about half of set-outs are related to brake issues, so the value

[209] Electronically Controlled Pneumatic Brake Systems, Final Rulemaking, Regulatory Analysis, Federal Railroad Administration, June 2008, Docket ID: FRA-2006-26175-0065 at www.regulations.gov

from the original analysis is halved. For example, a car may need to be set out because of a defective hand hold, and the likelihood of such a set-out is not affected by the presence of ECP brakes. In this analysis FRA assumes one brake caused set-out avoided on 10 percent of 1,000 miles trips or one brake induced set-out avoided for every 10,000 miles of unit train travel. To update the numbers from 2008 to 2014, PHMSA and FRA used labor cost index values reported by AAR to the STB because the primary cost of a set-out is employee time. In Q2 2014 Class I railroads reported their labor cost index to be 388.1, and they had reported the labor cost index in Q2 2008 to have been 313.6. The ratio is 1.2376, which when multiplied by the 2008 estimate of $400, yields a 2014 estimate of $495.

In the NPRM, PHMSA and FRA estimated that when all ECP-equipped locomotives have joined the fleet, each set of locomotives will operate 220 miles per day, 360 days per year, for a total of 79,200 miles per year. PHMSA and FRA estimate that 900 locomotives will be equipped, and that unit trains will require three locomotives each, thus there will be 300 sets, operating a total of 23,760,000 miles per year. If one set-out is avoided every 10,000 miles, these sets will avoid 2,376 set-outs a year, for an annual savings of $1,176,181 at full installation. PHMSA and FRA also increased the estimated real cost each year after 2014 to account for increased real wages, which are estimated to grow at 1.18 percent per year from the base year of 2015.[210] There is no reason to believe that the labor hours required for setting out a car will decrease because of improved productivity. As discussed above, PHMSA and FRA estimates one-third of full benefit in 2016, two-thirds of full benefit in 2017 and full benefit from 2018 onward. In the NPRM 10,000 train-miles with 100 cars per train implied 1,000,000 car-miles per setout avoided. In this analysis of the final rule, where the average length of ethanol unit trains is estimated at 80 cars instead of 100 cars, the value had to be converted to car-miles, but remained at an estimated 1,000,000 car-miles per set-out avoided.

Table BR13: Set Out Relief Values Estimated for the NPRM Analysis

			Discounted Value	
			Discount Factor	
Year	**Wage Inflator**	**Benefit**	**7% Discount**	**3% Discount**
2015	101.18%	0	$0	$0
2016	102.37%	$401,367	$350,570	$378,327
2017	103.58%	$812,207	$663,003	$743,285
2018	104.80%	$1,232,687	$940,411	$1,095,226

[210] These wages were adjusted in accordance with the "Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses." http://www.dot.gov/regulations/economic-values-used-in-analysis.

Table BR13: Set Out Relief Values Estimated for the NPRM Analysis				
2019	106.04%	$1,247,232	$889,259	$1,075,874
2020	107.29%	$1,261,950	$840,890	$1,056,863
2021	108.56%	$1,276,841	$795,152	$1,038,188
2022	109.84%	$1,291,907	$751,902	$1,019,844
2023	111.14%	$1,307,152	$711,004	$1,001,823
2024	112.45%	$1,322,576	$672,331	$984,121
2025	113.77%	$1,338,183	$635,761	$966,732
2026	115.12%	$1,353,973	$601,180	$949,650
2027	116.47%	$1,369,950	$568,481	$932,869
2028	117.85%	$1,386,116	$537,560	$916,386
2029	119.24%	$1,402,472	$508,320	$900,193
2030	120.65%	$1,419,021	$480,672	$884,287
2031	122.07%	$1,435,765	$454,527	$868,662
2032	123.51%	$1,452,707	$429,804	$853,313
2033	124.97%	$1,469,849	$406,426	$838,235
2034	126.44%	$1,487,194	$384,319	$823,423
Total			$11,621,571	$17,327,300

Previous analyses had used one set out avoided per 10,000 train-miles, assuming 100 cars per train. This works out to one set out avoided per 1,000,000 car-miles, This final rule analysis uses the car miles estimates shown in Table BR 11, above, the unit savings estimate of $495 per set out avoided in 2014, and one set out avoided per 1,000,000 car-miles, inflated by growth in real wages. The results, used to calculate the business benefits in this analysis, are presented in Table BR14.

Table BR14– Set-Out Relief Final Rule Estimates				
			Discounted Value	
			Discount Factor	
Year	**Wage Inflator**	**Benefit**	**7%**	**3%**
2015	$0	$0	-	-
2016	$0	$0	-	-
2017	$137,920	$154,621	$148,220	$166,167
2018	$283,451	$330,114	$303,031	$352,918
2019	$430,812	$521,219	$458,684	$554,941
2020	$581,731	$731,142	$617,162	$775,673
2021	$691,158	$902,408	$733,235	$957,346
2022	$668,982	$907,375	$693,290	$940,345
2023	$647,925	$912,943	$655,582	$923,732
2024	$621,687	$909,992	$621,687	$909,992
2025	$586,203	$891,374	$586,203	$891,374
2026	$542,913	$857,608	$542,913	$857,608
2027	$504,446	$827,790	$504,446	$827,790
2028	$468,286	$798,295	$468,286	$798,295
2029	$434,098	$768,752	$434,098	$768,752
2030	$401,646	$738,904	$401,646	$738,904
2031	$372,329	$711,570	$372,329	$711,570
2032	$344,738	$684,426	$344,738	$684,426
2033	$319,832	$659,639	$319,832	$659,639
2034	$296,873	$636,066	$296,873	$636,066
Total			$8,335,030	$12,944,239

The total discounted value of this benefit is $8,335,030 at 7 percent and $12,944,239 at 3 percent.

Single Car Air Brake Test (SCABT) Relief

The SCABT relief from the 2008 rule only affects trains equipped with ECP brakes. Since the final rule requires ECP brakes, equipped trains could, but as explained below, will not, realize

the potential benefits permitted by the 2008 rule, which allowed, but did not require ECP brakes. The item shown as "Single Brake Test" in the table below was described in the 2008 analysis: [211]

"The [2008] rule also modifies periodic maintenance requirements, including certain SCABTs, in order to tailor the requirements more specifically for ECP brake systems. Due to the ECP brake system's ability to continuously monitor the condition of a car's air brakes, FRA believes that less frequent SCABTs are justified on ECP brake equipment. Railroads may retrofit ECP brake systems on existing cars equipped with conventional pneumatic brake systems. Accordingly, the performance of a SCABT is required prior to returning the car to revenue service after the application of the ECP brake system. This is already required when installing a new brake system, thus the cost of this test is not avoided with ECP brake systems. However, the self-monitoring capabilities of ECP brake systems may extend the time period to perform SCABTs. This would reduce the number of single car tests that must be performed on cars equipped with ECP brakes. Freight cars with conventional brakes receive a SCABT every time they are on the repair track if they haven't received one within the past 12 months. It has been estimated by the AAR that more than 99 percent of cars are on a repair track every 2 years. FRA estimates the benefits of SCABT avoidance once at the beginning of a five year period coinciding with the ECP brake installation rate, and once every 5 years thereafter. This estimate is conservative, and it is possible that these cars may avoid up to 2.5 SCABTs every 5-year period. Because this estimate is so conservative, this benefit is taken at the beginning of the 5-year period. The cost of the SCABT is either $89.22 for a manual test or $100.85 for an instrument test. FRA used the average value of these two tests, $95.04, to calculate this benefit."

The exception for ECP-equipped cars to avoid SCABTs when they are on a shop or repair track does not apply to dual mode ECP brake systems under 49 CFR §232.611(f). Dual mode systems can operate either in a conventionally equipped train with standard air brakes or in an ECP equipped train. PHMSA and FRA believe all affected tank cars will be equipped with dual mode systems, not stand-alone systems, because the railroads will need the flexibility to haul the cars in trains not equipped with ECP, whether moving them for repairs, or hauling commodities in a train not equipped with ECP brakes, perhaps because a short haul is involved, or the car has been shifted into service carrying a commodity not affected by the proposed rule. Thus, there is no benefit estimated for this provision.

Class I and Class IA Brake Test Relief

The Class I and Class IA Brake Test relief from the 2008 rule only affects trains equipped with ECP brakes. Since the final rule requires ECP brakes, equipped trains will realize the potential

[211] Electronically Controlled Pneumatic Brake Systems, Final Rulemaking, Regulatory Analysis, Federal Railroad Administration, June 2008, Docket ID: FRA-2006-26175-0065 at www.regulations.gov

benefits permitted by the 2008 rule, which allowed, but did not require ECP brakes. The 2008 analysis[212] described the benefits of relief from "Class I and Class IA Brake Tests" requirements:

"The rule allows ECP brake-equipped trains to travel to their destination, not to exceed 3,500 miles. Extended haul and other trains are currently limited to 1,500 miles and 1,000 miles, respectively, between brake inspections. Thus, the rule will eliminate, conservatively, at least one Class I brake test or two Class IA brake tests on a long distance train equipped with ECP brakes, depending on current operations. The long-haul, unit, and unit-like trains are assumed to convert to ECP brake systems. Trains with conventional brakes that meet FRA's extended haul requirements are given 1,500 miles between intermediate terminal brake inspections. These requirements limit the number of times an extended haul train on extended haul can pick up or set out cars en route, and impose additional recordkeeping. Many long-haul unit trains are extended haul trains. FRA estimates that there are 40,000 extended haul trains that operate each year.

"The single largest cost savings in the brake inspection category is expected to be the elimination of the 1,000-mile intermediate terminal brake test (Class IA test) for trains operating in the ECP brake mode. Under current regulations, conventionally-braked trains are required to stop at a terminal for inspection every 1,000 miles, where the brakes on each car are inspected to determine whether they are fully functioning.

"With ECP brake systems, there is constant wire-based monitoring of the brake condition on all cars and hence a reduced need to stop and physically inspect the brakes every 1,000 miles after initial terminal departure. More than 10 years ago, the AAR calculated the cost of the intermediate brake test (Class IA) to be $450 per train, including both the direct cost of the inspection and delay costs of setting out or repairing defective equipment when identified.[213] To reflect current costs as confirmed in the Booz Allen Hamilton report, FRA assumes that this cost is at least 10 percent greater 10 years later, or $500 per train. The Class I test is substantially more involved than the Class IA test and is estimated to cost $1,000 per train. Trains operating under the extended haul provisions, estimated at 40,000 trains each year, must receive a Class I test at the beginning of the extended haul segment and a Class I test at the end of the Class I segment if the train goes further than 1,500 miles. Thus, a train that travels more than 1,500 miles and uses the extended haul provision would receive two Class I tests ($2,000). With ECP brakes, the same train would only receive a Class I test at initial terminal, which would permit it to travel to 3,500 miles, or to its destination. A cycle train is a train that operates in a continuous

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[212] Electronically Controlled Pneumatic Brake Systems, Final Rulemaking, Regulatory Analysis, Federal Railroad Administration, June 2008, Docket ID: FRA-2006-26175-0065 at www.regulations.gov

[213] FRA commissioned a report by Booz Allen Hamilton (BAH) to describe a path to ECP brake implementation. A copy of this report has been placed in the public docket to this rulemaking at Docket Number FRA-2006-26175

loop(s), without a specific destination, that requires a Class IA test at a location not to exceed 1,000 miles. Every 3,000 miles, a cycle train must receive a Class I test. Many cycle trains are used in coal service, which will implement ECP brakes. With ECP brakes, the Class I test is still required, but two Class I A tests are eliminated. There are approximately 14,000 cycle trains that operate each year that are estimated to receive relief from two Class IA brake tests ($1,000).

"Using the AAR Fact Book, the Freight Commodity Statistics, waybill data, and information provided by one Class I carrier, FRA estimates that approximately 178,071 trains travel more than 1,000 miles to destination and 88,045 (including the 40,000 extended haul trains) travel more than 1,500 miles to destination each year. Of these trains, approximately 25 percent operate over 2,000 miles and thus will receive relief from two Class IA brakes tests (2 X $500 = $1,000). Since extended haul trains are not required to have any Class IA brake tests they would not benefit from this relief."

As described above, in analyzing the NPRM, PHMSA and FRA assumed that ECP-equipped trains will travel 23,760,000 miles per year. PHMSA and FRA assumed that ECP equipped trains will function as cycle trains, running as a unit, at least from the point at which the trains are assembled, and often on a longer term basis from the point at which they are loaded, to the destination, typically a refinery, and back to the original assembly point or loading facility. PHMSA and FRA, in analyzing the NPRM, further assumed that each train will avoid 2 Class IA brake tests every three thousand miles, or 15,840 brake tests per year.

In this analysis of the final rule PHMSA and FRA have changed the assumption to reflect that extended haul trains are allowed by regulation to go as far as 1500 miles before requiring a Class I brake test, and that some unit trains are being broken up at the unloading facility. As noted above, this analysis assumes that Crude Oil HHFUTs will travel an average of 1,000 miles, and Ethanol HHFUTs will travel an average of 1,300 miles. Trains traveling a round trip, returning residue cars to the loading facility would be traveling 2,000 miles and 2,600 miles, respectively and would need at least one Class I brake test were they not equipped with ECP brakes. This would be true if the train were broken and reassembled at either end of the round trip. It is possible that initial makeup of the unit train might be as residue cars, remaining a unit train through loading. Some trains might remain as unit trains through loading and unloading, in which case the number of Class I brake tests avoided might be greater than one per round trip. As a conservative assumption, PHMSA and FRA assume a benefit of one brake test avoided per round trip. The number of trains is estimated at one per 100 carloads in HHFUTs for crude oil and one per 80 carloads in HHFUTs for ethanol.

The value per brake test, $500 is updated to 2014 values using the same multiplier for labor costs, 1.2376, yielding a savings per test of $618.78. Because this estimate is based on data from 1998 that is updated only to account for inflation (as measured by wage growth since this primarily a labor function, and there is no reason to assume that the hours of labor required to perform a brake test will be reduced by increased productivity), PHMSA and FRA sought, but did not receive comment on this. This number largely represents wage costs, and is increased by a real factor of 1.18 percent per year past 2014. The total cost of brake tests avoided over 20 years will be $51,480,542, discounted at 7 percent per year, or $80,261,134, discounted at 3 per cent per year.

Table BR 15: Class I Brake Test Relief Values from the NPRM Analysis				
Values Estimated for the NPRM Analysis			Discounted Value	
			Discount Factor	
Year	Wage Inflator	Benefit	7% Discount	3% Discount
2015	101.18%	-	$0	$0
2016	102.37%	$3,344,728	$2,921,415	$3,152,727
2017	103.58%	$6,768,393	$5,525,024	$6,194,038
2018	104.80%	$10,272,389	$7,836,757	$9,126,885
2019	106.04%	$10,393,604	$7,410,496	$8,965,614
2020	107.29%	$10,516,248	$7,007,420	$8,807,192
2021	108.56%	$10,640,340	$6,626,269	$8,651,570
2022	109.84%	$10,765,896	$6,265,849	$8,498,698
2023	111.14%	$10,892,933	$5,925,034	$8,348,526
2024	112.45%	$11,021,470	$5,602,756	$8,201,009
2025	113.77%	$11,151,523	$5,298,008	$8,056,098
2026	115.12%	$11,283,111	$5,009,836	$7,913,747
2027	116.47%	$11,416,252	$4,737,339	$7,773,912
2028	117.85%	$11,550,964	$4,479,663	$7,636,548
2029	119.24%	$11,687,265	$4,236,003	$7,501,611
2030	120.65%	$11,825,175	$4,005,596	$7,369,058
2031	122.07%	$11,964,712	$3,787,721	$7,238,847
2032	123.51%	$12,105,896	$3,581,698	$7,110,938
2033	124.97%	$12,248,745	$3,386,880	$6,985,288
2034	126.44%	$12,393,280	$3,202,659	$6,861,859
Total			$96,846,424	$144,394,164

Table BR16- Class I Brake Test Relief Final Rule Estimates				
Adjusted for Both Phase-In and Flows				
Year	**Wage Inflator**	**Benefit**	**Discounted Value**	
			Discount Factor	
			7%	**3%**
2015	101.18%	$0	$0	$0
2016	102.37%	$0	$0	$0
2017	103.58%	$1,006,720	$821,784	$921,292
2018	104.80%	$2,118,600	$1,616,270	$1,882,349
2019	106.04%	$3,496,442	$2,492,915	$3,016,061
2020	107.29%	$5,056,942	$3,369,654	$4,235,110
2021	108.56%	$6,852,822	$4,267,593	$5,571,971
2022	109.84%	$7,133,806	$4,151,940	$5,631,492
2023	111.14%	$7,380,862	$4,014,700	$5,656,816
2024	112.45%	$7,553,682	$3,839,909	$5,620,649
2025	113.77%	$7,664,708	$3,641,447	$5,537,148
2026	115.12%	$7,732,963	$3,433,528	$5,423,745
2027	116.47%	$7,661,777	$3,179,365	$5,217,297
2028	117.85%	$7,615,992	$2,953,613	$5,035,068
2029	119.24%	$7,563,625	$2,741,406	$4,854,803
2030	120.65%	$7,500,827	$2,540,790	$4,674,268
2031	122.07%	$7,424,279	$2,350,337	$4,491,811
2032	123.51%	$7,362,662	$2,178,346	$4,324,788
2033	124.97%	$7,292,736	$2,016,502	$4,158,945
2034	126.44%	$7,238,029	$1,870,444	$4,007,521
Total			$51,480,542	$80,261,134

Impact of Dynamic Braking

In the NPRM, PHMSA and FRA described ECP brake system business benefits from more efficient fuel consumption and reduced wheel wear. In comments provided to PHMSA and FRA during meetings with the Office of Information and Regulatory Affairs of the Office of Management and Budget held under Executive Order 12866, AAR asserts that a significant portion the benefits claimed in the analysis of the NPRM for wheel savings and fuel savings are currently realized through the use of dynamic braking. Dynamic braking is an alternative to pneumatic brakes for slowing a train in non-emergency situation, and its use allows a train to operate more efficiently. When trains use dynamic braking and not ECP brakes, they do not get business benefits from ECP brakes. AAR analyzed data from a small number of trips of ECP-equipped trains and found that 89 percent of the time that the train was braking, it was not using ECP brakes in whole or in part. AAR therefore estimated that 85 percent of the fuel and wheel

savings benefits are currently realized through use of dynamic brakes. PHMSA and FRA accept that the fuel and wheel savings should be reduced to account for the use of dynamic braking, but the reduction should be smaller than 85 percent. The ability to use ECP brakes on top of the dynamic brakes further improves fuel efficiency by as much as five percent above dynamic braking alone, depending on the routes and railroad practices. For instance, Canadian Pacific achieved a fuel savings of 5.4 percent from ECP brakes used in conjunction with dynamic brakes during testing in Golden, British Columbia, a route which has particularly advantageous terrain for maximizing the fuel benefits associated with ECP braking.[214] Because not all terrain will be as advantageous as this test region, PHMSA is reducing estimated fuel efficiency benefits by 50 percent, corresponding to a fuel improvement rate of 2.5 percent. However, this estimate is conservative and likely understates the fuel efficiency benefits. PHMSA and FRA also accept that wheel savings costs should be reduced to account for the use of dynamic braking, but that they should be reduced by less than 85 percent. Railroads will continue to experience brake induced wheel wear where pneumatic brakes are used, but if the railroads rely on dynamic braking they will face a cost not considered in other parts of the analysis, increased rail wear, with attendant increased risk of broken rail accidents and increased track maintenance costs. PHMSA and FRA estimate that the use of dynamic braking in conjunction with ECP braking would reduce the combined wheel wear and dynamic brake induced rail wear by at least as much as 25 percent of the wheel wear benefits estimated using the methodology and assumptions used in analyzing the NPRM. Therefore, PHMSA and FRA are reducing the estimated wheel wear benefit from ECP brakes by 75 percent. PHMSA and FRA view this as a conservative assumption.

Wheel Savings

The Wheel Savings only affects trains equipped with ECP brakes. Since the final rule requires ECP brakes, equipped trains will realize the potential benefits permitted by the 2008 rule, which allowed, but did not require ECP brakes. "Wheel Savings" were described in the 2008 analysis:

"Wheels are but one component of a freight car that could provide maintenance savings under ECP brake operation. Wheel damage is reduced due to more uniform braking and better train handling. One of the ways in which ECP brakes contribute to a reduction in premature wheel wear is by lowering the average brake friction temperature on the wheels through more consistent braking. Excessive buildup of heat in the wheels is a major contributor to wheel failure. The industry expenditure on wheel replacements warrants singling them out as a significant benefit of conversion to ECP brake systems. A recent study by the TTCI found that the rail freight industry spends 37 percent of its annual freight car repair cost of $1.5 billion on

[214] Wachs, K., Aronian, A., Bell, S. Electronically-Controlled Pneumatic (ECP) Brake Experience at Canadian Pacific. *Proceedings from the 2011 International Heavy Haul Conference*, Calgary AB, 2011, available at http://www.ihha.net/IHA/uploads/assets/fin00258.pdf.

wheel replacements—representing $555 million. These data are for calendar year (CY) 2000, and the costs are undoubtedly higher now. Wheelsets need to be replaced because they are either worn out or damaged. Brake-related failures were found to reduce the life of wheelsets by more than 50 percent."

Per wheelset replacement costs are now at least $1,250 and could range as high as $1,500. Using the lower end of this range ($1,250), the resulting 25 percent increase in per unit wheel replacement costs translates into a conservative estimate of $700 million in annual wheel repair expenditures, when applied to the CY 2000 data. Assuming that ECP brakes would eliminate half of all brake-related wheel defects, this would translate into $175 million annually for the entire freight car fleet. Heavy-haul, high-mileage cars would account for a disproportionately high share of these savings. Using the same adjustment of 61 percent for ECP brake-related savings, the annual savings for the entire fleet of $175 million (× 0.61) = $106,750,000. The 20-year wheel savings discounted at 7 percent equals $714,495,572.

PHMSA and FRA assume that wheel replacement cost in freight cars is proportional to their mileage. In analyzing the NPRM, PHMSA and FRA used locomotive numbers as a surrogate for share of total miles. In this final analysis, the estimates are based on the ratio of carload miles in this final analysis to carload miles implied in the analysis of the NPRM. This analysis estimates that the industry will equip far more locomotives, but there is no longer an assumption that these locomotives will be used almost exclusively to haul HHFT unit trains. In the NPRM analysis PHMSA and FRA estimate there would be 900 locomotives out of an industry wide fleet of 24,250 mainline locomotives, or 3.71 percent. The number of locomotives estimated in this analysis reflects that the locomotives will not be used exclusively in service affected by the final rule.

This analysis continues to use estimates from the NPRM, adjusting those estimates to take into account relative car miles, thus the number of locomotives is no longer a direct input to the estimates of business benefits in this analysis. If the industry wide cost of wheelset replacement was $555 million in year 2000 (as noted above), and according to the AAR fact book, there were 34,950,000,000 car miles in 2000, the cost per car-mile was $0.01588. This number was adjusted for labor costs. The labor index submitted by Class I railroads to the STB for Q2 2000 was 242.6, while the 2014 value was 388.1. The ratio of the 2014 value to the Q2 2000 value, used here as a multiplier, is 1.598. Thus the cost per car mile, in 2014 dollars would be $0.02538. Since brake-related failures account for only half of wheelset life reduction, the addressable value of wheelset life reduction is $0.01269 per car mile. Saving half of that would save $0.006348 per car mile. Car miles were those shown in Table BR12, above.

There were no comments to the docket regarding the various multipliers, but as noted above, the total savings were reduced by 75 percent to account for use of dynamic braking. Although these values are largely labor costs, unlike other costs, PHMSA and FRA believe that shop labor costs subject to real wage growth are also subject to offsetting increases in productivity, so they are not multiplied by an annual real wage growth factor.

Table BR 17: Wheel Savings Values Estimated for the NPRM Analysis			
		Discounted Value	
		Discount Factor	
Year	Benefit	7% Discount	3% Discount
2015	0	$0	$0
2016	$2,718,987	$2,374,869	$2,562,906
2017	$5,437,974	$4,439,007	$4,976,517
2018	$8,156,962	$6,222,907	$7,247,355
2019	$8,156,962	$5,815,801	$7,036,267
2020	$8,156,962	$5,435,328	$6,831,327
2021	$8,156,962	$5,079,746	$6,632,356
2022	$8,156,962	$4,747,426	$6,439,181
2023	$8,156,962	$4,436,847	$6,251,632
2024	$8,156,962	$4,146,586	$6,069,546
2025	$8,156,962	$3,875,314	$5,892,763
2026	$8,156,962	$3,621,789	$5,721,129
2027	$8,156,962	$3,384,849	$5,554,494
2028	$8,156,962	$3,163,410	$5,392,713
2029	$8,156,962	$2,956,458	$5,235,643
2030	$8,156,962	$2,763,045	$5,083,149
2031	$8,156,962	$2,582,285	$4,935,096
2032	$8,156,962	$2,413,351	$4,791,355
2033	$8,156,962	$2,255,468	$4,651,801
2034	$8,156,962	$2,107,914	$4,516,312
Total		$71,822,399	$105,821,542

Table BR 18: Wheel Savings Final Rule Estimates			
		Discounted Value	
		Discount Factor	
Year	**Benefit**	**7% Discount**	**3% Discount**
2015	$0	$0	$0
2016	$0	$0	$0
2017	$502,793	$410,429	$460,127
2018	$1,045,542	$797,639	$928,951
2019	$1,704,282	$1,215,130	$1,470,129
2020	$2,434,935	$1,622,500	$2,039,220
2021	$3,259,738	$2,030,001	$2,650,466
2022	$3,356,336	$1,953,418	$2,649,523
2023	$3,435,085	$1,868,459	$2,632,707
2024	$3,475,718	$1,766,879	$2,586,261
2025	$3,485,607	$1,655,987	$2,518,077
2026	$3,475,712	$1,543,258	$2,437,795
2027	$3,404,198	$1,412,621	$2,318,093
2028	$3,344,944	$1,297,227	$2,211,402
2029	$3,283,784	$1,190,194	$2,107,736
2030	$3,219,141	$1,090,435	$2,006,063
2031	$3,149,811	$997,150	$1,905,688
2032	$3,087,853	$913,584	$1,813,788
2033	$3,023,488	$836,020	$1,724,253
2034	$2,966,405	$766,575	$1,642,427
Total		$23,367,506	$36,102,703

Fuel Savings

In the 2008 analysis, fuel savings were calculated as a proportion of fuel used. This remains a reasonable assumption today, because even though locomotives use fewer gallons per ton-mile, ECP braking still improves fuel efficiency by 5 percent when it is used instead of dynamic braking;[215] therefore, improved ECP braking still improves fuel efficiency by 5 percent of the

[215] 'Benefit-Cost Analysis and Implementation Plan for Electronically Controlled Pneumatic Braking Technology inthe Railroad Industry,' Booz Allen Hamilton, August 2006, p. III-2. The Booz Allen figures were confirmed by tests performed on Canadian Pacific cited by "Electronically-Controlled Pneumatic (ECP) Brake Experience at

new fuel consumption rate. A simple way to account for both factors at one time is to estimate the total expenditure on fuel, and then calculate the fuel savings assuming that ECP brakes will continue to save the same percentage of fuel. According to their reports to the STB, Class I railroads spent $3,202,554,000 on fuel in Q2 2014, or an annual rate of $12,810,216,000. In analyzing the NPRM, PHMSA and FRA estimated that 900 locomotives will be affected by the final rule, of out of a potential fleet of 24,250, and PHMSA and FRA assume that these locomotives use fuel in proportion to their share of the total locomotive fleet. Thus, the fuel expenditure total is multiplied by 0.03711 (= 900 /24,250). The estimated quarterly fuel use of the 900 locomotives is $475,430,697. (.03711 * $12,810,216,000) The savings from ECP brakes would be 5 percent of $475,430,697; or $23,771,535 per year. While benefits in the NPRM analysis were based on locomotives, that analysis assumed that locomotives assigned to unit train service hauling crude oil and ethanol would not be used for other purposes, so in this analysis it is appropriate to base benefits on relative car-miles. This savings might be greater if the added weight of the enhanced tank cars causes more fuel use, but PHMSA and FRA are not certain that fuel use will increase, because aerodynamic effects may offset increases in weight. Therefore, the measure of ECP induced fuel savings does not take into account the impacts of increased weight, which assumption, when used to estimate business benefits, is a conservative assumption. This savings is not adjusted for any changes in real wages, and, in the NPRM analysis, accrued at full value beginning in year 2018.

In this analysis, fuels savings estimates are based on car-miles. Class I railroads used $11,597,000,000 in fuel, and hauled 35,253,000,000 car-miles in 2013, according to the AAR fact book. Thus the cost of fuel per car-miles was $0.3290, and saving 5 percent would save $0.0164 per car mile. These savings are reduced by 50 percent to account for savings already generated by dynamic braking, as discussed above. The car-miles are those derived for Table BR12. The savings estimated are presented in Table BR20, below.

Canadian Pacific", Wachs, K., Aronian, A., Bell, S. *Proceedings from the 2011 International Heavy Haul Conference*, Calgary AB, 2011, p. 2-4. http://www.ihha.net/IHA/uploads/assets/fin00258.pdf

Table BR19: Fuel Savings, NPRM Estimates			
Values Estimated for the NPRM Analysis			
		Discount Factor	
Year	**Benefit**	**7% Discount**	**3% Discount**
2015	0	$0	$0
2016	$7,923,845	$6,920,993	$7,468,984
2017	$15,847,690	$12,936,436	$14,502,881
2018	$23,771,535	$18,135,190	$21,120,701
2019	$23,771,535	$16,948,776	$20,505,535
2020	$23,771,535	$15,839,977	$19,908,286
2021	$23,771,535	$14,803,717	$19,328,433
2022	$23,771,535	$13,835,250	$18,765,469
2023	$23,771,535	$12,930,140	$18,218,902
2024	$23,771,535	$12,084,243	$17,688,254
2025	$23,771,535	$11,293,685	$17,173,063
2026	$23,771,535	$10,554,846	$16,672,876
2027	$23,771,535	$9,864,342	$16,187,259
2028	$23,771,535	$9,219,011	$15,715,785
2029	$23,771,535	$8,615,898	$15,258,044
2030	$23,771,535	$8,052,241	$14,813,635
2031	$23,771,535	$7,525,459	$14,382,170
2032	$23,771,535	$7,033,139	$13,963,271
2033	$23,771,535	$6,573,027	$13,556,574
2034	$23,771,535	$6,143,016	$13,161,722
Total		$209,309,387	$308,391,844

Table BR20- Fuel Savings, Final Rule Estimates			
		Discounted Value	
		Discount Factor	
Year	Benefit	7% Discount	3% Discount
2015	$0	$0	$0
2016	$0	$0	$0
2017	$2,606,502	$2,127,682	$2,385,318
2018	$5,420,140	$4,134,998	$4,815,724
2019	$8,835,077	$6,299,288	$7,621,215
2020	$12,622,814	$8,411,114	$10,571,408
2021	$16,898,632	$10,523,619	$13,740,134
2022	$17,399,401	$10,126,610	$13,735,248
2023	$17,807,639	$9,686,176	$13,648,072
2024	$18,018,280	$9,159,580	$13,407,293
2025	$18,069,545	$8,584,711	$13,053,824
2026	$18,018,251	$8,000,319	$12,637,639
2027	$17,647,517	$7,323,092	$12,017,100
2028	$17,340,340	$6,724,883	$11,464,008
2029	$17,023,286	$6,170,022	$10,926,600
2030	$16,688,176	$5,652,863	$10,399,520
2031	$16,328,764	$5,169,269	$9,879,171
2032	$16,007,572	$4,736,063	$9,402,762
2033	$15,673,898	$4,333,963	$8,938,605
2034	$15,377,978	$3,973,962	$8,514,414
Total		$121,138,213	$187,158,053

Table BR21: Total ECP Business Benefits		
Benefit	Discounted Value	
	Discount Factor	
	7% Discount	3% Discount
Set Out Relief	$8,335,030	$12,944,239
Class IA brake test	$51,480,542	$80,261,134
Wheel Savings	$23,367,506	$36,102,703
Fuel Savings	$121,138,213	$187,158,053
Total	$204,321,291	$316,466,129

Reduction in Locomotives

As discussed earlier, due to the efficiencies of ECP brakes, fewer tank cars will be needed to meet demand. PHMSA and FRA estimate that 4,835 less tank cars would need to be purchased. As fewer tank cars are required, there would be a commensurate reduction in the number of locomotives needed. There would be 4,220 fewer crude cars. Assuming 100 cars per train, ECP brakes help to reduce the number of trains it takes to make the same number of movements over time – in this case 42.2 trains.[216] There would also be 615 fewer ethanol cars. Using an 80-car train, ECP brakes help to reduce the number of trains by 7.7.[217] Most trains require three locomotives per trainset. The 49.9 trainsets [218] would result in the rail industry needing 149.7 fewer locomotives [219] to operate.

The current cost of a new locomotive is approximately $2,000,000. If we used the full cost of a locomotive, we would see a savings of over $299.3 million.[220] However, the railroads may continue to purchase these locomotives in order to update their fleet, or move these locomotives into other services. PHMSA and FRA believe it would be conservative to use only 25 percent of the cost of a locomotive to attribute to the locomotive savings that would occur due to ECP brakes. In this analysis, PHMSA and FRA realized all of the costs for the locomotive savings in year six, given that that is the final year for allowed retrofits/new construction. Over a twenty year period, the total business benefit attributed to a reduction of locomotives would be $74.8 million; discounted at 7 percent, the value is $49.9 million and is $62.7 million discounted at 3 percent.

Non-Quantified Benefits

As we reviewed the efficiencies of ECP brakes, many of the benefits were discussed and monetized. However, there are many benefits that we have not quantified in this analysis. Although they have not yet been quantified, they should be considered as they provide significant benefits that will be seen throughout the rail industry. These are both safety and business benefits.

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[216] 4,220 (tank cars) / 100 (cars per train) = 42.2 (number of train sets)

[217] 615 (tank cars) / 80 (cars per train) = 7.7 (number of train sets)

[218] 42.2 (crude oil trains reduced) + 7.7 (ethanol trains avoided) = 49.9 (total trains avoided)

[219] 49.9 (total trains reduced) * 3 (average number of locomotives on a train) = 149.7 (total locomotives reduced)

[220] 149.7 (locomotives) * $2,000,000 = $299,325,000

There are several additional safety benefits of ECP brakes that have not been monetized. Due to the shorter stopping distances and brake system monitoring associated with ECP braking, these include fewer and less-severe collisions with obstacles on the railroad, including vehicles stuck on grade crossings; fewer and less-severe train-to-train collisions; reduced chances of runaway trains; and fewer train-handling accidents.

As PTC is implemented, trains sets that operate in ECP brakes can have enhanced braking algorithms with lower variance. PTC and ECP brake systems should work together seamlessly to provide faster braking and enhanced train handling. ECP electronic communication networks can also be configured to transmit car-born sensor data for non-air brake purposes.

ECP brakes will eliminate the majority of dragging brake issues. It can also significantly reduce the possibility of a runaway train. Runaway trains can occur due to a depletion of the main reservoir air. This would be reduced with ECP brakes as the train line operates at a higher pressure and continuously recharges the car reservoirs, as opposed to conventional brakes, which cannot recharge the reservoirs while the brakes are applied. ECP brakes can also reduce undesired emergency applications which could prevent derailments, and increase fuel savings to an even greater extent than that specifically estimated in this analysis.

Although these benefits have not been quantified, they should be considered when looking at the impact ECP brakes will have on the rail network.

Summary of Benefits

Over a twenty-year period, the total benefits of the ECP braking systems would range between $470.3million and $613.4 million, discounted at 7 percent. Total benefits would range between $711.5 million and $932.5 million, discounted at 3 percent.

1. Alternatives Considered

The NPRM included a proposal for broad implementation of ECP brakes on HHFTs and presented cost estimates of $500.2 with benefits ranging from $737.3 million to $1,758.6 million. Commenters responded that the installation costs that had taken into account efficiencies based on economies of scale resulting from broad application analyzed by FRA in 2006 were too low and provided other cost estimates. However, no basis was provided for most of the cost estimates provided. Commenters also responded that the benefits had been overstated in the NPRM, particularly because the analysis of tank car derailment and puncture was based on the assumption that all derailments would occur at the head end of the train, which would allow for the mitigation benefits of ECP to apply to all the tank cars in the consist. As discussed earlier in this RIA and the final rule, FRA has since updated its analysis to take into account points of derailment along the train consist based on actual past history of relevant accidents. Prompted by the input provided by commenters and reviewers, FRA conducted further analysis of the costs and benefits of ECP brakes and based on actual in-service experience identified additional business benefits that would result from such technology when applied high-utilization cars in dedicated trainsets. Thus, PHMSA and FRA reevaluated the alternative of the broader application approach proposed in the NPRM.

PHMSA and FRA also considered requiring that all tank cars travelling in trains in excess of 30 mph covered by the final rule be equipped with ECP brakes by no later than the outermost compliance date for full implementation of the tank car structural requirements. This would maximize safety benefits and provide maximum flexibility for tank car owners to move their cars between services and railroads to manage train consists. Under this alternative the demand for ECP brakes would be strongest, thereby increasing the likelihood that economies of scale in manufacture would result in lower unit prices. The safe transport of high hazard flammable materials requires a system safety approach that includes accident mitigation and avoidance through structural and operational requirements. ECP brake systems enhance safety in both of these areas. ECP brakes provide accident prevention safety benefits without imposing the negative impacts on velocity that commenters noted the more stringent speed restrictions proposed in the NPRM would. The following analysis estimates the costs and benefits of an alternative under which all HHFT trainsets, including those with 70 or fewer crude and/or ethanol cars, are equipped and may utilize ECP brakes.

ECP Installation Costs (Tank Cars)

For the HHFUT ECP requirement of the final rule, PHMSA and FRA use a weighted average unit cost estimate of $7,633 (one third new construction at $7,300 and two thirds retrofit at $7,800)[221] for ECP brakes. Applying the ECP brake requirement to the larger tank car population alters the relative composition of the impacted fleet because more ethanol cars are included and we assume that they will be retrofits versus new construction. Accordingly, under the alternative considered scenario, that average is raised to $7,700 (20% new construction and 80% retrofit).[222] PHMSA and FRA estimate that all 93,379 tank cars would be required to have ECP brakes – the entire US fleet of crude oil and ethanol cars. It is reasonable to assume that all HHFUT's (70+ tank car unit trains) would be still be equipped with ECP brakes by the January 1, 2021 for PG I and May 1, 2023 for PG II deadlines as both railroads and shippers seek to take advantage of the ECP brake business benefits. The remainder of the tank cars would be equipped over the next one and a half years. Cars used outside of HHFUTs are probably not used in such high-service dedicated trainsets. The total estimated cost to equip these tank cars with ECP brakes would be $719.0 million. Discounted at 3 and 7 percent over a 20-year period costs are $614.3 and $506.20 million respectively.

Buffer cars are required for the transportation of the impacted commodities by train. However, PHMSA and FRA do not expect that additional buffer cars would be equipped with ECP brakes

[221] [(1/3) (Fleet to be new construction) * $7,300 (cost of new construction)] + [(2/3) (Fleet to be retrofit) * $7,800 (cost of retrofit)] = $7,675

[222] [.20 (Fleet to be new construction) * $7,300 (cost of new construction)] + [.80 (Fleet to be retrofit) * $7,800 (cost of retrofit)] = $7,700

for the additional service impacted since these additional cars would not operate exclusively in ECP brake mode like those in HHFUTs. Any additional buffer cars that are required for the added service would simply operate using runaround cables that would be kept onboard the ECP-equipped locomotives. In total, 1,266[223] buffer cars would be needed. The total cost of those additional buffer cars would be $1.3 million. Twenty-year discounted costs at 3 and 7 percent are $1.1 and $1.0 million, respectively. The per-unit and total costs are the same under both the actual requirement and the alternative considered since we assume that runaround cables will be used to meet the requirements for trains not covered by the HHFUT definition.

As previously discussed, the batteries and cables would need to be replaced on all cars ever five years regardless of use. The per-tank car cost for batteries is $87 and for cables is $300. Over a twenty-year period, the total cost of batteries and cable replacement is $91.3 million. Costs discounted at 3 and 7 percent over a 20 year period are $60.7 and $36.6 million, respectively.

PHMSA and FRA do not assume that the additional tank cars that are retrofitted under the alternative considered will benefit from the same in-service efficiencies of ECP brakes as the cars in exclusive HHFUTs. In general, most of these additional cars will continue to operate with conventional air brakes, using a two-way EOT or DP yielding nominal business benefits. Therefore, the total cost savings of ECP efficiencies, with a reduction of tank cars, will remain the same under both scenarios. The total costs savings of ECP brakes would be $14.5[224] million. Over a 20-year period the cost are $12.1 million discounted at 3 percent and $9.7 million discounted at 7 percent.

Summary of ECP Installation Costs (Tank Cars)

For the 20-year period of analysis, the estimated total cost related to ECP brakes on tank cars is $797.1 million. Total discounted costs are $664.1 million (3 percent) and $534.2 million (7 percent).

ECP Installation Costs (Locomotives)

As discussed in the previous section, it is reasonable to assume that all equipment in HHFUT's would still be equipped with ECP brakes by the January 1, 2021 or May 1, 2023 deadline. The remainder of the locomotives would be equipped over the next one and a half years. For the final rule ECP brake requirement analysis, we estimate the locomotive cost based on equipping 2,532 locomotives. In order to capture the additional ECP installation costs that would result from the broader alternative considered, the alternative scenario assumes approximately 5,000

[223] 633 (estimated number of HHFUT at peak year) *2 (number of buffer cars required for each train) = 1,266 (buffer cars needed)

[224] 4,835 (fewer tank cars) * $3,000 (incremental cost difference) = $14,505,000

locomotives would need to be equipped or about twice as many. To meet this higher rate of installations, it is no longer realistic to assume that all would be on new locomotives. The Class I Railroad's locomotive purchasing projections of over 1,000 new locomotives per year would likely be insufficient since they may be needed for other service. Therefore, PHMSA and FRA assume that 20 percent of the ECP brake installations on locomotives would be retrofits, and 80 percent would be add-ons for new locomotives. The ECP brake add-on for new locomotives is estimated to cost $40,000 per locomotive. AAR commented that the cost for retrofit is $83,300 and this analysis is using that as its estimate. This results in a weighted average cost of $48,660.[225] Over a 20-year period, the total cost to equip the locomotives with ECP brakes is $243.3 million. Discounted at 3 and 7 percent the costs are $204.4 and $164.6 million, respectively.

PHMSA and FRA believe that each locomotive would be equipped with run around cables. Over a 20-year period, it would cost $5.0 million to purchase these additional cables. These totals discounted are $4.2 million and $3.4 million using a 3 and a 7 percent discount rate.

In the original analysis, PHMSA and FRA included cost for and asset manager to oversee the two fleets, one with ECP and one non-ECP. With all tank cars equipped with ECP, there would be no need for an additional asset manager.

For the 20-year period of analysis, the estimated total cost of ECP brakes on locomotives is $248.3 million. Discounted at 3 and 7 percent, the total cost is $208.6 million and $168.0 million, respectively.

Training Costs for ECP Brakes

In the previous sections PHMSA and FRA analyzed the routes of the HHFUT's to determine how many crews could be affected. Using the waybill sample, FRA estimated that approximately 68 percent of the total ton-miles were on routes that had crude or ethanol unit trains. Commenters noted that the under a full fleet equipped scenario all crews would have to be trained. Accordingly, the cost to train all supervisors and crews is $70.9 million. Discounted at 3 and 7 percent, the total cost is $65.0 million and $58.2 million, respectively.

Summary of Costs

For the 20-year period, the total cost for installation and operation of ECP brakes is $1,116.3 million. Discounted values at 3 and 7 percent are $937.6 million and $760.4 million respectively.

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[225] [$83,300 (cost to retrofit a locomotive) * .20 (percent of retrofitted locomotives)] + [$40,00 (cost of add on for new locomotives) * .80 (percent of new locomotives)] = $48,660

Benefits of ECP Brakes

Benefits for ECP brakes are attained only when entire trains operate in ECP mode. Based on PHMSA and FRA's assumptions that the utilization rate for HHFUT is 16.0 cycles per year, 45 percent of the tank cars would likely operate in manifest trains – thus they were not included in the benefits estimate for the HHFUT ECP brake analysis. If these additional tank cars were equipped with ECP brakes to meet the alternative considered these cars would not often operate in ECP mode. A small percentage of the carloads originated might shift from manifest trains to dedicated ECP train service. That would be a business decision based on the particular circumstances surrounding those moves. These would likely include a portion of trains with 69 or fewer tank cars that only carry a single commodity.

Crude Oil Service -- After evaluating the waybill sample PHMSA and FRA found that 84 percent of the crude oil carloads were on trainsets that had 70+ tank cars. Additional crude oil trains with fewer than 70 cars would be equipped with ECP brakes and benefit from the accident prevention and mitigation benefits. Because the additional number of trains captured would be small the corresponding increase in safety benefits would also be small. In addition, because the trains themselves would have fewer crude oil cars, the opportunity for derailment and puncture would be reduced and thus the overall potential safety benefit per train in this category. For the purposes of this analysis, PHMSA and FRA have increased the estimate of crude oil tank cars that would operate using ECP brakes by 2 percentage points. We have slightly adjusted our phase in for ECP braking benefits based on these trainsets that would operate under with ECP braking systems. Tables 22 and 23 shows the resulting accident mitigation safety benefits for crude oil traffic for LCE and HCE.

Table BR22: Total LCE ECP Benefits for Crude Oil Traffic by Year

Year	Total Damages	Percentage of Crude HHFUT of Total Carloads	Percent of Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 179,915,412	55.6%	0.0%	19.7%	$ -	$ -	$ -
2016	$ 176,427,442	55.6%	0.0%	19.7%	$ -	$ -	$ -
2017	$ 182,777,809	56.2%	18.0%	19.7%	$ 3,644,990	$ 2,975,398	$ 3,335,682
2018	$ 196,334,749	58.1%	38.0%	19.7%	$ 8,545,295	$ 6,519,164	$ 7,592,384
2019	$ 208,471,811	59.7%	58.0%	19.7%	$ 14,211,271	$ 10,132,440	$ 12,258,767
2020	$ 221,509,522	61.0%	78.0%	19.7%	$ 20,762,978	$ 13,835,249	$ 17,388,667
2021	$ 222,699,151	61.0%	98.0%	19.7%	$ 26,231,143	$ 16,335,438	$ 21,328,320
2022	$ 223,063,891	60.6%	98.5%	19.7%	$ 26,225,946	$ 15,263,739	$ 20,703,004
2023	$ 208,678,220	60.6%	99.0%	19.7%	$ 24,665,549	$ 13,416,424	$ 18,904,089
2024	$ 223,774,639	60.7%	99.5%	19.7%	$ 26,605,212	$ 13,524,741	$ 19,796,777
2025	$ 223,247,669	60.6%	100.0%	19.7%	$ 26,650,490	$ 12,661,456	$ 19,252,881
2026	$ 219,084,383	60.1%	100.0%	19.7%	$ 25,943,811	$ 11,519,362	$ 18,196,467
2027	$ 201,212,338	59.7%	100.0%	19.7%	$ 23,659,719	$ 9,817,942	$ 16,111,117
2028	$ 212,100,606	59.2%	100.0%	19.7%	$ 24,750,899	$ 9,598,825	$ 16,363,260
2029	$ 208,330,088	58.8%	100.0%	19.7%	$ 24,116,117	$ 8,740,791	$ 15,479,218
2030	$ 204,293,980	58.2%	100.0%	19.7%	$ 23,428,029	$ 7,935,884	$ 14,599,573
2031	$ 200,686,778	57.7%	100.0%	19.7%	$ 22,815,986	$ 7,222,957	$ 13,804,047
2032	$ 196,924,311	57.2%	100.0%	19.7%	$ 22,184,575	$ 6,563,615	$ 13,031,099
2033	$ 193,606,475	56.7%	100.0%	19.7%	$ 21,619,024	$ 5,977,840	$ 12,329,027
2034	$ 190,456,652	56.2%	100.0%	19.7%	$ 21,069,565	$ 5,444,776	$ 11,665,707
				Total	**$ 387,130,598**	**$ 177,486,041**	**$ 272,140,087**

Table BR23: Total HCE ECP Benefits for Crude Oil Traffic by Year

Year	Total Damages	Percentage of Crude HHFUT of Total Carloads	Percent of Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 140,250,000	55.6%	0.0%	19.7%	$ -	$ -	$ -
2016	$ 140,250,000	55.6%	0.0%	19.7%	$ -	$ -	$ -
2017	$ 140,250,000	56.2%	18.0%	19.7%	$ 2,796,892	$ 2,283,097	$ 2,559,553
2018	$ 140,250,000	58.1%	38.0%	19.7%	$ 6,104,256	$ 4,656,908	$ 5,423,552
2019	$ 140,250,000	59.7%	58.0%	19.7%	$ 9,560,672	$ 6,816,627	$ 8,247,120
2020	$ 140,250,000	61.0%	78.0%	19.7%	$ 13,146,196	$ 8,759,866	$ 11,009,733
2021	$ 140,250,000	61.0%	98.0%	19.7%	$ 16,519,676	$ 10,287,624	$ 13,432,008
2022	$ 140,250,000	60.6%	98.5%	19.7%	$ 16,489,396	$ 9,596,979	$ 13,016,882
2023	$ 140,250,000	60.6%	99.0%	19.7%	$ 16,577,404	$ 9,017,010	$ 12,705,200
2024	$ 140,250,000	60.7%	99.5%	19.7%	$ 16,674,727	$ 8,476,586	$ 12,407,563
2025	$ 140,250,000	60.6%	100.0%	19.7%	$ 16,742,532	$ 7,954,256	$ 12,095,161
2026	$ 140,250,000	60.1%	100.0%	19.7%	$ 16,608,302	$ 7,374,285	$ 11,648,729
2027	$ 140,250,000	59.7%	100.0%	19.7%	$ 16,491,412	$ 6,843,350	$ 11,229,849
2028	$ 140,250,000	59.2%	100.0%	19.7%	$ 16,366,354	$ 6,347,154	$ 10,820,088
2029	$ 140,250,000	58.8%	100.0%	19.7%	$ 16,235,223	$ 5,884,392	$ 10,420,772
2030	$ 140,250,000	58.2%	100.0%	19.7%	$ 16,083,592	$ 5,448,069	$ 10,022,763
2031	$ 140,250,000	57.7%	100.0%	19.7%	$ 15,944,957	$ 5,047,765	$ 9,646,961
2032	$ 140,250,000	57.2%	100.0%	19.7%	$ 15,799,911	$ 4,674,624	$ 9,280,782
2033	$ 140,250,000	56.7%	100.0%	19.7%	$ 15,660,985	$ 4,330,393	$ 8,931,241
2034	$ 140,250,000	56.2%	100.0%	19.7%	$ 15,515,376	$ 4,009,468	$ 8,590,487
				Total	**$ 259,317,864**	**$ 117,808,451**	**$ 181,488,444**

Ethanol Service – Evaluation of the 2013 waybill sample data for ethanol shipments indicates that 47 percent of the carloads were on trains that had 70 or more tank cars. In addition, 13 percent of the ethanol carloads were on trains carrying between 16-60 carloads. Given the distribution of ethanol carloads and crude oil carloads across the different carload groups, a larger percentage increase would be seen in ethanol traffic captured by the broader application of ECP brakes. For the purposes of evaluating this alternative, PHMSA and FRA have increased the ethanol traffic car that would use ECP brakes by 8 percentage points. We have slightly adjusted our phase in for ECP braking benefits based on these trainsets that would operate under with ECP braking systems. Tables 24 and 25 shows the new accident mitigation safety benefits that would accrue from trains carrying ethanol cars and operating in ECP brake mode for LCE and HCE.

Table BR24: Total LCE ECP Benefits for Ethanol Traffic by Year

Year	Total Damages	Percentage of Ethanol HHFUT of Total Carloads	Percent Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 179,915,412	19.1%	0.0%	19.7%	$ -	$ -	$ -
2016	$ 176,427,442	19.1%	0.0%	19.7%	$ -	$ -	$ -
2017	$ 182,777,809	18.7%	15.0%	19.7%	$ 1,009,323	$ 823,908	$ 923,674
2018	$ 196,334,749	17.5%	35.0%	19.7%	$ 2,368,086	$ 1,806,601	$ 2,104,013
2019	$ 208,471,811	16.5%	55.0%	19.7%	$ 3,735,674	$ 2,663,484	$ 3,222,425
2020	$ 221,509,522	15.7%	75.0%	19.7%	$ 5,137,350	$ 3,423,233	$ 4,302,450
2021	$ 222,699,151	15.7%	96.0%	19.7%	$ 6,608,525	$ 4,115,458	$ 5,373,336
2022	$ 223,063,891	16.0%	97.0%	19.7%	$ 6,800,970	$ 3,958,226	$ 5,368,748
2023	$ 208,678,220	15.9%	98.0%	19.7%	$ 6,423,976	$ 3,494,217	$ 4,923,443
2024	$ 223,774,639	15.9%	99.0%	19.7%	$ 6,945,444	$ 3,530,711	$ 5,168,063
2025	$ 223,247,669	16.0%	100.0%	19.7%	$ 7,015,059	$ 3,332,804	$ 5,067,828
2026	$ 219,084,383	16.3%	100.0%	19.7%	$ 7,015,897	$ 3,115,142	$ 4,920,809
2027	$ 201,212,338	16.5%	100.0%	19.7%	$ 6,548,866	$ 2,717,547	$ 4,459,459
2028	$ 212,100,606	16.8%	100.0%	19.7%	$ 7,022,000	$ 2,723,253	$ 4,642,369
2029	$ 208,330,088	17.1%	100.0%	19.7%	$ 7,019,477	$ 2,544,181	$ 4,505,535
2030	$ 204,293,980	17.4%	100.0%	19.7%	$ 7,022,171	$ 2,378,652	$ 4,375,985
2031	$ 200,686,778	17.8%	100.0%	19.7%	$ 7,022,743	$ 2,223,220	$ 4,248,875
2032	$ 196,924,311	18.1%	100.0%	19.7%	$ 7,018,959	$ 2,076,657	$ 4,122,899
2033	$ 193,606,475	18.4%	100.0%	19.7%	$ 7,021,121	$ 1,941,398	$ 4,004,047
2034	$ 190,456,652	18.7%	100.0%	19.7%	$ 7,031,052	$ 1,816,957	$ 3,892,923
				Total	**$ 108,766,691**	**$ 48,685,651**	**$ 75,626,880**

Table BR25: Total HCE ECP Benefits for Ethanol Traffic by Year

Year	Total Damages	Percentage of Ethanol HHFUT of Total Carloads	Percent Operating Equipped with ECP	ECP Effectiveness Ratio	ECP Benefits	Present Value Discounted at 7%	Present Value Discounted at 3%
2015	$ 140,250,000	19.1%	0.0%	19.7%	$ -	$ -	$ -
2016	$ 140,250,000	19.1%	0.0%	19.7%	$ -	$ -	$ -
2017	$ 140,250,000	18.7%	15.0%	19.7%	$ 774,479	$ 632,206	$ 708,758
2018	$ 140,250,000	17.5%	35.0%	19.7%	$ 1,691,621	$ 1,290,530	$ 1,502,983
2019	$ 140,250,000	16.5%	55.0%	19.7%	$ 2,513,185	$ 1,791,866	$ 2,167,896
2020	$ 140,250,000	15.7%	75.0%	19.7%	$ 3,252,742	$ 2,167,439	$ 2,724,120
2021	$ 140,250,000	15.7%	96.0%	19.7%	$ 4,161,874	$ 2,591,806	$ 3,383,984
2022	$ 140,250,000	16.0%	97.0%	19.7%	$ 4,276,066	$ 2,488,710	$ 3,375,566
2023	$ 140,250,000	15.9%	98.0%	19.7%	$ 4,317,473	$ 2,348,419	$ 3,308,984
2024	$ 140,250,000	15.9%	99.0%	19.7%	$ 4,353,034	$ 2,212,862	$ 3,239,066
2025	$ 140,250,000	16.0%	100.0%	19.7%	$ 4,407,043	$ 2,093,754	$ 3,183,741
2026	$ 140,250,000	16.3%	100.0%	19.7%	$ 4,491,327	$ 1,994,203	$ 3,150,126
2027	$ 140,250,000	16.5%	100.0%	19.7%	$ 4,564,722	$ 1,894,198	$ 3,108,354
2028	$ 140,250,000	16.8%	100.0%	19.7%	$ 4,643,247	$ 1,800,731	$ 3,069,733
2029	$ 140,250,000	17.1%	100.0%	19.7%	$ 4,725,585	$ 1,712,770	$ 3,033,173
2030	$ 140,250,000	17.4%	100.0%	19.7%	$ 4,820,795	$ 1,632,970	$ 3,004,160
2031	$ 140,250,000	17.8%	100.0%	19.7%	$ 4,907,845	$ 1,553,698	$ 2,969,327
2032	$ 140,250,000	18.1%	100.0%	19.7%	$ 4,998,921	$ 1,479,000	$ 2,936,339
2033	$ 140,250,000	18.4%	100.0%	19.7%	$ 5,086,153	$ 1,406,364	$ 2,900,562
2034	$ 140,250,000	18.7%	100.0%	19.7%	$ 5,177,582	$ 1,337,986	$ 2,866,702
				Total	**$ 73,163,695**	**$ 32,429,510**	**$ 50,633,575**

Although the majority of benefits associated with accident avoidance would be captured by the final rule HHFUT requirement, a small number of accidents may also be avoided as additional smaller unit trains operate in ECP mode. In the final rule we project that 7.4 percent of the locomotive fleet would operate with ECP brakes. Crude shipments impacted increase by 2 percentage points and the ethanol shipments by 8 percentage points under the broader alternative, this equates to an additional 21 ECP trains, which in turn translates to a 3 percent increase in accident avoidance benefits results or a total of 7.7 percent of the locomotives in the fleet would operate with ECP brakes. Under the broader ECP brake scenario, the total ECP accident avoidance would be to be $2.0 million under the broader ECP brake scenario, discounted at 7 percent and 3 percent the totals would be $.8 million and $1.4 million, respectively.

ECP Business Benefits

As noted above, for the analysis of the alternative considered no additional business benefits (excluding equipment reduction) are included, given the more limited opportunity for cars in non-HHFUT trains to be operated in ECP brake mode. Total discounted benefits (excluding reduction in equipment, which is discussed below) are presented in the table below:

Table BR26: Total ECP Business Benefits		
Benefit	**Discounted Value**	
	Discount Factor	
	7% Discount	**3% Discount**
Set Out Relief	$8,335,030	$12,944,239
Class IA brake test	$51,480,542	$80,261,134
Wheel Savings	$23,367,506	$36,102,703

Table BR26: Total ECP Business Benefits		
Benefit	**Discounted Value**	
	Discount Factor	
	7% Discount	**3% Discount**
Fuel Savings	$121,138,213	$187,158,053
Total	$204,321,291	$316,466,129

Locomotives would still be eliminated under the alternative. Over a twenty year period, the total business benefit attributed to a reduction of locomotives would be $74.8 million; discounted at 7 percent, the value is $49.9 million and is $62.7 million discounted at 3 percent.

Summary of Benefits

Over a twenty-year period, the total benefits of the broader ECP brake requirement would range between $485.4 million and $635.7 million, discounted at 7 percent. Total benefits would range between $733.6 million and $965.7 million, discounted at 3 percent.

Conclusion for Alternatives Considered

The alternative of equipping all of the covered tank cars with ECP brakes allows for additional flexibility for car owners and railroads and results in higher safety benefit, however compliance costs are significantly higher. The total costs for this alternative is $760.4 million with benefits ranging from and $485.4 million and $635.7 million, discounted at 7 percent. This provides net benefits (both negative) ranging between -$275.4 million and -$126.6 million, discounted at 7 percent.

The total cost for the final rule as presented in Section 3 of this analysis is $492.0 million, with benefits ranging from $470.3 million to $613.4 million. This provides net benefits ranging between -$21.7 million and $121.4 million, discounted at 7 percent.

The costs for the alternative of requiring ECP brakes for all covered tank cars would exceed the costs of the final rule by $268.4 million over a twenty-year period, discounted at 7 percent. This is a 55 percent increase in costs. The benefits for this alternative also exceed the costs of the final rule, but not by the same margin. In this alternative, the benefits would increase between $15.1 million and $22.3 million, discounted at 7 percent. This is only a 3.2 – 3.6 percent increase over the benefits in the final rule.

PHMSA and FRA believe that the approach focused on HHFUT for ECP brakes results in a better return on investment per unit equipped. This limits the costs of this regulation and ensures optimal utilization of ECP brakes. Under the final rule operational requirements for ECP brakes on HHFUTs, industry may equip additional equipment with ECP brakes on a case-by-case basis to the extent they are able to realize benefits that cover costs.

H. Requirement Area 5 – Classification of Unrefined Petroleum-Based Products

Final Action: PHMSA is requiring any offeror of unrefined petroleum-based products for transportation to develop, implement, and update a sampling and testing program related to the classification and identification of properties for packaging selection of these materials.

1. Determination of Need

Under § 173.22 of the HMR, it is the offeror's responsibility to properly "class and describe the hazardous material in accordance with parts 172 and 173 of the HMR." A hazardous material must be classified in accordance with the appropriate hazard class definitions included in Part 173 of the HMR. The offeror must also identify relevant properties to follow packaging requirements. Once an offeror has determined the hazard class of the material, the offeror must select the most appropriate shipping name from the § 172.101 Hazardous Materials Table (HMT).

Relevant properties to properly classify describe, and package unrefined petroleum-based products include, but are not limited to the following: flash point; boiling point; corrosivity; specific gravity at loading; reference temperatures; and the presence and concentration of specific compounds such as sulfur. This information enables an offeror to properly classify a hazardous material, select the most appropriate shipping description, and the proper HMR-authorized packaging for transportation of that hazardous material. Proper classification and characterization is especially important when dealing with a material such as unrefined petroleum-based products, including crude oil, as these materials' properties are variable. Such information and determination of the authorized packaging also ensures that the required tank car outage, or unfilled capacity, can be maintained in accordance with § 173.24(a).

Crude oil transported by rail is often derived from different sources and is then blended, complicating proper classification and characterization of the material. PHMSA and FRA audits of crude oil loading facilities indicate that the classification of crude oil being transported by rail is often based solely on a generic Safety Data Sheet (SDS). The data on these sheets only provides a material classification and a range of material properties. This SDS information is typically provided by the consignee (the person to whom the shipment is to be delivered) to the offeror. In these instances, it is possible that there has been no validation of the crude oil properties. Further, FRA's audits indicate that SDS information is often not assembled from any recently conducted tests or from testing for the many different sources (wells) of the crude oil.

In the rail environment, it is critical that the existence and concentration of specific elements or compounds be identified, along with the corrosivity of the materials to the tank cars and service equipment. Proper identification of these elements will enable a shipper to ensure the reliability of the tank car. Proper identification also enables a shipper to determine if there is a need for an interior coating or lining, alternative materials of construction for valves and fittings, and performance requirements for fluid sealing elements, such as gaskets and o-rings.

In addition, recommendation R-14-6, issued by the NTSB, recognized the importance of sufficient testing and documentation of the physical and chemical characteristics of hazardous materials to ensure the proper classification, packaging, and record-keeping of products offered in transportation. Correct classification decisions are essential for the selection of proper equipment (tank, service equipment, interior lining or coating) and use, or maintenance and qualification of the equipment. The statement on a shipping paper is the offeror's certification that a hazardous material, is properly classified, described, packaged, marked and labeled, and in proper condition for transportation according to the applicable regulations of DOT. Packaging decisions are based on the information provided by the offeror. Incorrect classification and characterization of hazardous material may lead to failures throughout the transportation system.

2. Action by the United States and Canada

U.S. Action

Any improper classification of crude oil and subsequent shipment in an unauthorized tank car diminishes industry efforts to improve the safety of transporting hazardous materials, and violates the requirements of the HMR. The proper classification of a hazardous material is a key requirement under the HMR, as it dictates exactly which other requirements apply, such as specific operational controls and proper packaging selection. Classification is simply ensuring that the proper hazard class and Packing Group (if applicable) have been assigned to a particular material. Characterization is a complete description of the properties necessary to comply with all requirements during the transportation cycle. Characterization includes the identification of the effects that a material has on both the reliability and safety of the packaging. Proper classification and characterization is especially important when dealing with a material such as unrefined petroleum-based products, including crude oil, as these materials are variable. The characterization of crude oil may vary greatly depending on time, temperature, and the methods used to extract and process the material. In contrast, the classification and characterization of manufactured products is generally well understood and consistent.

Improper classification and characterization can also affect operational requirements under the HMR. Offerors and carriers must ensure that outage is considered when loading a tank car. Section 173.24b(a) of the HMR sets the minimum tank car outage for hazardous materials at one percent at a reference temperature that is based on the existence of tank car insulation. A crude oil offeror must know the specific gravity of the hazardous material at the reference temperature as well as the temperature and specific gravity of the material at that temperature when loaded. This information is then used to calculate the total quantity that can be safely loaded into the car to comply with the one percent outage requirement. If the outage is not properly calculated because the material's specific gravity is unknown (or is provided only as a range), the tank car could be loaded such that if the temperature increases during transportation, the tank will become shell-full, increasing the likelihood of a leak from the valve fittings or manway.

The final sampling and testing program is intended to ensure that:

1) the proper regulatory requirements are applied to shipments to minimize the risk of incident;
2) first responders have accurate information in the event of a train accident; and

3) the characteristics of the material are known and fully considered so that offerors and carriers are aware of and mitigate and potential threats to integrity of rail tank cars.

Canadian Action

On July 2, 2014 Canada published "SOR/2014-152, Published". The final rule requires that consignors and carriers present classification assessment information upon request and also requires a shipper's certification on the shipping paper so that there is someone to hold responsible for that classification. The shipper's certification is something we currently require under the HMR already. In accordance with this rule:

1) The consignor must classify these dangerous goods on the basis of samples.
2) The consignor must make available to the Minister, on reasonable notice given by the Minister, a document that explains the sampling method and includes the following information:

    a. the scope of the method;
    b. the sampling apparatus;
    c. the sampling procedures;
    d. the frequency and conditions of sampling; and
    e. a description of the quality control management system in place.

I. Alternatives Considered to Classification of Unrefined Petroleum-Based Products

1. Status Quo

The industry would continue the status quo and sample the material based on the existing classification and characterization methods. Rail derailment and accidents involving crude oil shipments that have been improperly classified may create potential risks for emergency responders. If PHMSA chose to take no action, then there would be no added costs or benefits to the rule.

2. Require Sampling and Testing Program

The properties of unrefined petroleum-based products, including crude oil, are variable based on time, method, and location of extraction. Whereas manufactured goods that undergo strict quality assurance tests to fall within defined parameters, unrefined petroleum-based products do not. The challenge they provide to classification is that the chemical makeup of raw material can vary over time and geographic location. While organic materials from oil and gas production pass through a "separator" to remove gas, sediment and water from crude, multiple hazardous materials can be commonly shipped from the well site: crude, natural gas condensate, and natural gas liquid.

Under this alternative, PHMSA requires a documented sampling and testing plan for shippers of these unrefined petroleum-based products in commerce. This plan will enable PHMSA and shippers of this commodity to more easily ascertain the specific classification and characteristics of the commodity and help to minimize potential risks when responding to a derailment and accident. In Recommendation R-14-6, the NTSB recognized the importance of sufficient testing and documentation of the physical and chemical characteristics of hazardous materials. The testing and sampling plan is required to address the following areas:

1) A frequency of sampling and testing that accounts for any appreciable variability of the material;
2) Sampling prior to the initial offering of the material for transportation and when changes that may affect the properties of the material occur;
3) Sampling methods that ensures a representative sample of the entire mixture, as offered, is collected;
4) Testing methods that enable classification of the material under the HMR;
5) Quality control measures for sample frequencies;
6) Duplicate samples or equivalent measures for quality assurance;
7) Criteria for modifying the sampling and testing program;
8) Testing or other appropriate methods used to identify properties of the mixture relevant to packaging requirements

Section 173.41(c) requires that the sampling and testing program be documented in writing and retained for as long as it remains in effect. The final requirement specifies that the sampling and testing program must be reviewed annually, at a minimum, and revised and/or updated as necessary to reflect changing circumstances § 173.41(d) mandates that each offeror required to develop and implement a sampling and testing program must maintain a copy of the sampling and testing program documentation (or an electronic file thereof) that is accessible at, or through, its principal place of business and must make the documentation available upon request, at a reasonable time and location, to an authorized official of DOT. Additionally, if any changes are made to the sampling and testing program, documentation that was updated, revised, or superseded must be retained for five additional years.

During the comment period, the majority of issues raised by commenters could have either been addressed by editorial revisions to the regulatory text or were outside of the scope of what was proposed in the rulemaking. Our focus centered on the applicability of which hazardous materials should be covered by the rulemaking:

Alternative 2a): Limit Applicability to Petroleum Crude Only

This option supports AAR comments. It does not fully address the risk posed by gaseous petroleum products, which have the same variability and classification risks as petroleum crude oil. The estimated number of offerors affected by this requirement is 1,748 offerors.[226] This dataset does not allow for separation of crude oil from petroleum gases and natural gas.

Alternative 2b): Limit Applicability to Unrefined Petroleum-Based Products

PHMSA has adopted this option. The majority of hazardous liquids and gases extracted from the earth are petroleum-based products. This option addresses the risks posed by unrefined petroleum-based products, which potentially have significant variability in their properties as a function of time, location, method of extraction, temperature at time of extraction, and the type and extent of conditioning or processing of the material. It further addresses commenter requests to clarify which hazardous materials are subject to the sampling and testing plan. Many commenters also supported inclusion of materials beyond petroleum crude oil only. The RIA for the NPRM only included petroleum-based products when analyzing mined liquids and gases. Therefore, this option was analyzed in the RIA for the NPRM. While, they savings from the proposed definitions are not quantified, the clarification ensures that additional offerors will not be inadvertently impacted. This option has been adjusted to reflect an updated dataset. The total number offerors affected by this requirement has increased from 1,538 offerors originally stated in the NPRM to 1,801.[227]

Alternative 2c): All Mined Liquids and Gases

This option was proposed in rulemaking, but no data was provided by commenters to describe benefits from expanding the definition beyond petroleum-based liquids and gases. Petroleum-based products were the only mined liquids and gases analyzed in the RIA for the NPRM, thus we have no additional information on the number of offerors and the costs and benefits of this requirement.

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[226] Offerors are determined using a subset of PHMSA registrants. The number of offerors reflects numbers from the latest data pull from the Active PHMSA Registration list, December 15th, 2014. Source designation and codes for the offerors are Crude Petroleum and Natural Gas Extraction (211111) and Petroleum Bulk Stations and Terminals (424710). Crude Petroleum and Natural Gas Extraction (186 Offerors) & Petroleum Bulk Stations and Terminals (1,562 Offerors).

[227] Offerors are determined using a subset of PHMSA registrants. The increased number of offerors reflects numbers from the latest data pull from the Active PHMSA Registration list, December 15th, 2014. Source designation and codes for the offerors are Crude Petroleum and Natural Gas Extraction (211111), Natural Gas Liquid Extraction (211112), & Petroleum Bulk Stations and Terminals (424710).

Costs

First Year - Development and Implementation

The costs are attributed to the time cost of developing then implementing the sampling plan. Costs associated with additional equipment for sampling or testing or changes in shipping behavior or equipment (such as increased use of lined tank cars) are not estimated. Since sampling and testing of these materials are already required to properly classify them, PHMSA assumes that shippers already have sampling methods and testing protocols in place and are compiling and organizing the testing results in some form. Therefore, PHMSA attributes low costs to the development of a testing and sampling plan. The final rule requires that a report compiling sampling and testing procedures and tracking testing results be produced and updated as necessary. The time necessary to document a sampling and testing program report is estimated at 40 hours per shipper.

PHMSA assumes a Chemical Engineer is the labor category most appropriate to describe sampling methodologies, testing protocols, and present test results. The median hourly wage for a Chemical Engineer is $46.02.[228] To calculate the hourly wage rates for every year of the analysis PHMSA takes into consideration the 1.18 percent annual growth rate in median real wages. [229] Inflating the 2013 wage by 1.18 percent gives us a 2014 wage of $46.56. We then inflate this wage by 60 percent to account for fringe benefits and overhead of $27.94 per hour, for a total weighted hourly wage of $74.50 in 2014. Following the same series of calculations (and holding fringe benefits constant at $27.94), the total weighted hourly wage in 2015, the first year of the analysis, is estimated at $75.05. PHMSA estimates there are 1,801 entities that offer unrefined petroleum-based products for transportation to which sampling and testing requirement could apply.[230]

These comprise of 186 offerors of petroleum/natural gas extraction, 53 offerors of natural gas liquid extraction, and 1,562 offerors of petroleum bulk stations/terminals. PHMSA assumes that the 1,801 entities include a modest number of offerors of 'refined' petroleum-based products. Thus the total number of 1,801 offerors subject to this requirement will yield a conservative cost estimate. Additionally, PHMSA estimates that each offeror would spend 40 hours for

[228] BLS May 2013 National Occupational Employment and Wage Estimates, available online at http://www.bls.gov/oes/current/oes_nat.htm#17-0000.

[229] Based on real wage growth forecasts from the Congressional Budget Office, DOT's guidance estimates that there will be an expected 1.18 percent annual growth rate in median real wages over the next 30 years (2013-2043). The wage rate in 2014 is calculated as follows: $46.02*1.0118 +$46.02*1.0118*0.6 = $74.50.

[230] Source: PHMSA Hazmat Intelligence Portal (HIP) based on NACIS Codes for 211111 – Crude Petroleum and Natural Gas Extraction; 211112 – Natural Gas Liquid Extraction; and 424710 – Petroleum Bulk Stations and Terminals. The data are for active PHMSA registrations.

development and implementation of the sampling and testing program. Thus, for offerors subject to the sampling and testing program, for alternative 2 b) PHMSA estimate the cost to develop and implement a sampling and testing program will be $5,407,000 (1,801 offerors x 40 hours/entity x $75.05/hour). The classification requirements already exist. The impact of this action is related only to the development and maintenance of the sampling and testing plan. We do not account for the time to collect and analyze samples.

As discussed above, for alternative 2a), PHMSA assumes that there are 1,748 offerors. As previously mentioned this dataset does not allow for separation of crude oil from petroleum gases and natural gas thus yielding a conservative cost estimate. PHMSA estimates the costs of this option for the initial year of the sampling and testing program to be $5,248,000 (1,748 offerors x 40 hours/entity x $75.05/hour).

Subsequent Year – Update

This final rule requires companies that offer unrefined petroleum-based products for transportation to update their sampling and testing program as necessary to account for changing circumstances. PHMSA assumes that companies will review and update their sampling and testing programs once a year. PHMSA estimates the costs with alternative 2b), the adopted alternative, to update a sampling and testing program will be on average $1,459,263 per year.[231] The costs to develop, implement and update sampling and testing program for alternatives 2a and 2b are shown in the table below.

Table CL1: Costs to Develop, Implement and Update Sampling and Testing Program		
Sampling and Testing Plan		
	Alternative 2a	**Alternative 2b**
Offerors	1,748	1,801
Initial Year Cost	$5,248,000	$5,407,000
Later Year Cost (Average over years 2-20)	$1,416,211	$1,459,263
20 Years Total, Undiscounted	$32,156,000	$33,133,000
7% Discount Rate	$18,377,913	$18,936,060
3% Discount Rate	$24,656,717	$25,405,702

[231] $1.46 million = 1,801 entities x 10 hours/company x $81.02/hour (average hourly rate calculated for the subsequent years of the analysis (years 2-20) is based on the expected 1.18 percent annual growth rate in median real wages as mentioned above).

Benefits

The sampling and testing program is intended to minimize the risk of incident by ensuring the proper regulatory requirements are applied to each shipment and mitigate the potential threats to the integrity of packagings, such as rail tank cars when the offerors and carriers know and fully consider the properties of the material. Proper classification and characterization is especially important when dealing with a material such as unrefined petroleum-based products, including crude oil, as these materials' properties are variable. Such information and determination of the authorized packaging also ensures that the required tank car outage, or unfilled capacity, can be maintained in accordance with § 173.24b(a).

In calculating the benefits for the change, we focused on crude oil, as we assume the vast majority of unrefined petroleum-based products transported by highway and rail is crude oil. Further, any unrefined petroleum-based products moving by highway or rail are required to be transported in more robust packaging than for liquids, such as crude oil. Further, crude oil accounted for most non-accident releases (NARs) by commodity in 2012, nearly doubling the next highest commodity (alcohols not otherwise specified, which accounts for a comparable annual volume transported by rail). FRA's data indicates that 98 percent of the NARs involved loaded tank cars. Also, less than 2 percent of the NARs occurred at the bottom outlet valve. Product releases through the top valves and fittings of tank cars when the hazardous material expands during transportation suggest that loading facilities may not know the specific gravity of the hazardous materials loaded into railroad tank cars, resulting in a lack of sufficient outage. We anticipate some reduction in NARs as a result of improved testing and characterization but did not include this reduction.

FRA's review of the One-Time Movement Approval (OTMA) data indicates an increasing number of derailment and accidents involving damage to tank cars in crude oil service in the form of severe corrosion of the internal surface of the tank, man way covers, and valves and fittings. A possible cause is contamination of the crude oil by materials used in the fracturing process that are corrosive to the tank car and service equipment. Therefore, when crude oil is loaded into tank cars, it is critical that that the existence and concentration of specific elements or compounds be identified, along with the corrosivity of the materials to the tank cars and service equipment. Proper identification of these elements will enable a shipper to ensure the reliability of the tank car. Proper identification also enables a shipper to determine if there is a need for an interior coating or lining, alternative materials of construction for valves and fittings, and performance requirements for fluid sealing elements, such as gaskets and o-rings. Thus, by requiring offerors to properly classify these materials, PHMSA expects the maintenance time for the tank cars to be reduced.

DOT assumes that the sampling and testing program will affect all projected lower-consequence damages associated with crude oil incidents. DOT has not limited this estimate to accidents that would have been prevented through appropriate classification and packaging of materials. PHMSA expects the final requirements to reduce the expected lower-consequence damages. PHMSA conducted a break-even analysis to determine the effectiveness rates for which the final sampling and testing requirement will be beneficial to society. The lower-consequence event damage estimates with the sampling and testing requirement over the next 20 years, a total of $ 4.1 billion (undiscounted) are as seen in the table below:

Table CL2: Total Undiscounted Estimated Damages over 20-Years						
Year	**Crude Carloads**	**Ethanol Carloads**	**Total carloads**	**Ratio of crude oil carloads to total carloads**	**Total Lower-Consequence Damages**	**Total Lower-Consequence Damages - Sampling and Testing**
1	723,699	394,977	1,118,676	$116,391,702.11	$116,391,702.11	$116,391,702.11
2	726,742	396,882	1,123,624	$114,110,442.69	$114,110,442.69	$114,110,442.69
3	761,028	402,736	1,163,764	$119,525,118.86	$119,525,118.86	$119,525,118.86
4	844,901	404,852	1,249,753	$132,732,968.65	$132,732,968.65	$132,732,968.65
5	920,347	406,310	1,326,657	$144,623,972.77	$144,623,972.77	$144,623,972.77
6	999,596	409,649	1,409,245	$157,119,615.22	$157,119,615.22	$157,119,615.22
7	1,004,852	411,575	1,416,427	$157,988,860.20	$157,988,860.20	$157,988,860.20
8	999,277	419,078	1,418,355	$157,155,730.27	$157,155,730.27	$157,155,730.27
9	999,486	418,797	1,418,283	$147,058,774.16	$147,058,774.16	$147,058,774.16
10	1,002,977	419,099	1,422,076	$157,826,175.32	$157,826,175.32	$157,826,175.32
11	999,375	418,947	1,418,322	$157,304,292.82	$157,304,292.82	$157,304,292.82
12	972,594	418,876	1,391,470	$153,133,130.00	$153,133,130.00	$153,133,130.00
13	950,327	418,923	1,369,250	$139,651,281.75	$139,651,281.75	$139,651,281.75
14	927,328	418,994	1,346,322	$146,091,968.16	$146,091,968.16	$146,091,968.16
15	903,274	418,718	1,321,992	$142,345,151.79	$142,345,151.79	$142,345,151.79
16	877,236	418,752	1,295,988	$138,283,713.92	$138,283,713.92	$138,283,713.92
17	854,058	418,658	1,272,716	$134,671,166.42	$134,671,166.42	$134,671,166.42
18	830,166	418,303	1,248,469	$130,944,274.60	$130,944,274.60	$130,944,274.60
19	808,749	418,301	1,227,050	$127,606,082.11	$127,606,082.11	$127,606,082.11
20	787,945	418,760	1,206,705	$124,362,927.69	$124,362,927.69	$124,362,927.69
				Total	$4,093,595,926	$2,798,927,349.52

Table CL3: Prevented Damages at the Break-Even Point		
Year	**Total Lower Consequence Damages - Sampling and Testing - 3% discounted**	**Total Lower Consequence Damages - Sampling and Testing - 7% discounted**
2015	$1,382,116	$1,401,495
2016	$1,315,560	$1,284,137
2017	$1,337,850	$1,257,075
2018	$1,442,413	$1,304,659
2019	$1,525,857	$1,328,540

Table CL3: Prevented Damages at the Break-Even Point		
2020	$1,609,411	$1,348,904
2021	$1,571,179	$1,267,633
2022	$1,517,372	$1,178,456
2023	$1,378,528	$1,030,600
2024	$1,436,371	$1,033,700
2025	$1,389,923	$962,881
2026	$1,313,658	$876,026
2027	$1,163,110	$746,636
2028	$1,181,313	$729,973
2029	$1,117,491	$664,721
2030	$1,053,987	$603,509
2031	$996,556	$549,293
2032	$940,754	$499,151
2033	$890,069	$454,604
2034	$842,183	$414,065
Total	$25,405,702	$18,936,060

To break even, the sampling and testing plan must achieve an overall effectiveness rate of 1.22% and 1.29% to be beneficial at three percent respectively seven percent discount rates. While it is ideal to consider damages that specifically resulted from improper classification, such information has not been developed. PHMSA believes that this provision will reduce the risk of release of these materials to the environment. As a result, we expect the sampling and testing plan to result in net benefits.

X. Comprehensive Benefits and Costs

A. Integration of Benefits for Entire Rule Options

To this point in the analysis, costs and benefits of the various provisions of the rule have been estimated on a stand-alone basis. If there were no overlap in either benefits or costs, total benefits and costs could be obtained by adding the costs of the various provisions together and adding benefits together to calculate totals for each. There is, however, some overlap, for both costs and benefits, between the effects of the tank car standard and the effects of ECP brakes and the speed restriction. The benefit estimate for each individual provision is obtained by multiplying the effectiveness of the provision by the total societal damages expected from unit train derailments. Because of this, adding the benefits for each provision to the benefits of other provisions results in some double counting of benefits.

A stylized example may help illustrate this issue. Consider a proposed rule that involves two provisions that are each expected to reduce expected damages by 30 percent. If the total

expected damages are $100 in the absence of the rule, each provision enacted on its own would be expected to generate $30 in benefits. However, those provisions together would not generate $60 in benefits. Instead, one provision should be applied first, generating $30 in benefits and leaving $70 in expected damages. The second provision would generate benefits equal to 30 percent of the $70 that remains of expected damages, or $21. Total benefits for this example would then be $51 ($30 + $21).

In this section, we make a series of calculations to eliminate these overlaps and develop and benefits of the final rule. We begin with the tank car standard, although it does not matter in which order these calculations are carried out—the total benefits for the final rule would be the same regardless of the order of calculation. We begin by presenting with lower-consequence damages, and higher consequence damages below. This is the pool of incidents that would be prevented or mitigated by the requirements of the final rule. We conduct these calculations using the mean HCE damages plus LCE damages. The final benefit figures for the 95th percentile benefit scenarios presented below are calculated exactly the same way, except the aggregate effectiveness of the rule is multiplied by the 20-year stream of 95th percentile HCE societal damage estimates rather than the mean HCE societal damage estimates.

Table CBC1. Low- and High-Consequence Baseline Damages, 2015-2034

Year	LCE Damages	Mean HCE
2015	$179,915,412	$140,250,000
2016	$176,427,442	$140,250,000
2017	$182,777,809	$140,250,000
2018	$196,334,749	$140,250,000
2019	$208,471,811	$140,250,000
2020	$221,509,522	$140,250,000
2021	$222,699,151	$140,250,000
2022	$223,063,891	$140,250,000
2023	$208,678,220	$140,250,000
2024	$223,774,639	$140,250,000
2025	$223,247,669	$140,250,000
2026	$219,084,383	$140,250,000
2027	$201,212,338	$140,250,000
2028	$212,100,606	$140,250,000
2029	$208,330,088	$140,250,000
2030	$204,293,980	$140,250,000
2031	$200,686,778	$140,250,000
2032	$196,924,311	$140,250,000
2033	$193,606,475	$140,250,000
2034	$190,456,652	$140,250,000
Total, Undiscounted	$4,093,595,927	$2,805,000,000
7% Discount Rate	$2,151,588,358	$1,485,810,498
3% Discount Rate	$3,037,792,406	$2,086,565,849

The series of calculations used to generate benefits for the comprehensive packages, starting with the tank car standard, then adding speed, then ECP braking as follows:

Equation CBC 1:

$$(\text{total low} - \text{consequence baseline damages}) - (\text{benefits of tank car standard}) = (\text{remaining damages})$$

Equation CBC 2:

$$(\text{remaining damages 1}) \times (\text{Speed effectiveness})) = (\text{marginal Speed benefits})$$

Equation CBC 3:

$$(\text{remaining damages 1}) - (\text{marginal Speed benefits}) = (\text{remaining damages 2})$$

Equation CBC 4:

$$(\text{remaining damages 2}) \times (\text{ECP effectiveness}) = (\text{marginal ECP benefits})$$

To obtain total LCE benefits, marginal speed benefits and marginal ECP brake benefits are added to the tank car benefits.

First, we subtract the benefits of the tank car option in question. For the Final Rule tank car, we subtract only the benefits of the tank car itself, not the ECP braking benefits, which are handled later in the calculations for options that include that car. This leaves us with a remaining damages pool, which provides the opportunity to achieve benefits from the next provision of the set of proposals. The calculations for estimating the benefits of the Option 1 tank car are presented in the tank car benefits section, but the dollar figures discounted at seven percent are presented below.

Table CBC2. Benefits of Final Rule Tank Car, 2015-2034 (7 Percent Discount)

Year	Total LCE Benefits
2015	$13,545
2016	$6,016,653
2017	$18,513,649
2018	$25,529,713
2019	$33,010,664
2020	$40,611,427
2021	$59,102,205
2022	$65,464,559
2023	$61,321,087
2024	$65,981,538
2025	$65,846,691
2026	$64,618,734
2027	$59,347,390
2028	$62,558,875
2029	$61,446,764
2030	$60,256,318

Table CBC2. Benefits of Final Rule Tank Car, 2015-2034 (7 Percent Discount)		
2031		$59,192,377
2032		$58,082,641
2033		$57,104,048
2034		$56,175,011
	Total Undiscounted	$980,193,889
	7% Discount Rate	$450,032,434.38
	3% Discount Rate	$688,875,430.36

These benefit figures are subtracted from the discounted low-consequence baseline damages to arrive at the remaining damages pool, which provides opportunities to achieve benefits from other provisions. Then, Speed effectiveness is applied to this remaining damage pool to generate speed benefits. These benefits are then subtracted from the damages minus tank car benefits to obtain damages minus tank car and marginal speed benefits. ECP braking effectiveness is then applied to these values to obtain marginal ECP benefits. Marginal ECP benefits are added to marginal speed benefits and tank car benefits to get the total LCE benefits of the rule. These calculations are carried out in the table below.

Table CBC3: Speed Marginal Effectiveness Benefits, 2015-2034 (Seven Percent Discount)			
Year	**LCE Damages - Tank Car Benefits**	**Speed Effectiveness**	**Speed Marginal Benefits**
2015	$179,901,868	8.75%	$15,747,889
2016	$170,410,789	7.44%	$12,677,130
2017	$164,264,160	5.93%	$9,743,497
2018	$170,805,036	4.91%	$8,382,546
2019	$175,461,146	3.86%	$6,780,140
2020	$180,898,095	3.14%	$5,684,382
2021	$163,596,946	1.39%	$2,276,899
2022	$157,599,332	0.59%	$925,585
2023	$147,357,133	0.34%	$500,442
2024	$157,793,101	0.00%	$0
2025	$157,400,978	0.00%	$0
2026	$154,465,650	0.00%	$0
2027	$141,864,947	0.00%	$0
2028	$149,541,731	0.00%	$0
2029	$146,883,324	0.00%	$0
2030	$144,037,662	0.00%	$0
2031	$141,494,401	0.00%	$0
2032	$138,841,670	0.00%	$0
2033	$136,502,426	0.00%	$0
2034	$134,281,641	0.00%	$0
		Total Undiscounted	$62,718,509
		7% Discount Rate	$50,989,684
		3% Discount Rate	$57,177,815

Table CBC4: ECP Braking Marginal Effectiveness Benefits, 2015-2034 (Seven Percent Discount)				
Year	**LCE Damages - Tank Car and Speed**	**ECP Effectiveness**	**Marginal ECP Benefits**	**Total LCE Benefits**
2015	$164,153,979	0.0%	$0	$15,761,434
2016	$157,733,659	0.0%	$0	$18,693,783
2017	$154,520,663	2.6%	$4,086,915	$32,344,061
2018	$162,422,491	5.4%	$8,729,823	$42,642,082
2019	$168,681,006	8.2%	$13,771,148	$53,561,952
2020	$175,213,712	11.0%	$19,282,361	$65,578,171
2021	$161,320,048	13.8%	$22,193,464	$83,572,568
2022	$156,673,747	14.0%	$21,909,220	$88,299,364
2023	$146,856,692	14.3%	$20,940,250	$82,761,779
2024	$157,793,101	14.4%	$22,721,991	$88,703,529
2025	$157,400,978	14.4%	$22,657,806	$88,504,497
2026	$154,465,650	14.4%	$22,171,663	$86,790,397
2027	$141,864,947	14.3%	$20,312,117	$79,659,507
2028	$149,541,731	14.3%	$21,353,904	$83,912,779
2029	$146,883,324	14.2%	$20,915,210	$82,361,974
2030	$144,037,662	14.2%	$20,443,009	$80,699,327
2031	$141,494,401	14.2%	$20,021,874	$79,214,251
2032	$138,841,670	14.1%	$19,584,727	$77,667,368
2033	$136,502,426	14.1%	$19,196,585	$76,300,633
2034	$134,281,641	14.0%	$18,824,292	$74,999,303
Total Undiscounted			$339,116,360	$1,382,028,759
7% Discount Rate			$156,306,575	$657,328,693
3% Discount Rate			$238,841,097	$984,894,343

Once total LCE benefits for the final rule have been obtained, they can be used to generate an aggregate effectiveness rate by dividing benefits by LCE damages in each year. These values can then be multiplied by the HCE damages to obtain HCE benefits. HCE benefits are then added to LCE benefits to get total safety benefits for the rule. These calculations are presented in the table below.

Table CBC5: Total Benefits, Mean HCE + LCE				
Year	**Aggregate Effectiveness**	**HCE Damages**	**HCE Benefits**	**Total Benefits**
2015	9%	$140,250,000	$12,286,557.52	$28,047,991
2016	11%	$140,250,000	$14,860,517.56	$33,554,301
2017	18%	$140,250,000	$24,818,409.96	$57,162,471
2018	22%	$140,250,000	$30,460,995.81	$73,103,078
2019	26%	$140,250,000	$36,033,954.73	$89,595,907
2020	30%	$140,250,000	$41,521,187.58	$107,099,358
2021	38%	$140,250,000	$52,631,779.86	$136,204,348
2022	40%	$140,250,000	$55,517,662.33	$143,817,026
2023	40%	$140,250,000	$55,623,147.69	$138,384,926

2024	40%	$140,250,000	$55,594,637.54	$144,298,167
2025	40%	$140,250,000	$55,600,829.90	$144,105,327
2026	40%	$140,250,000	$55,560,113.06	$142,350,510
2027	40%	$140,250,000	$55,524,656.25	$135,184,163
2028	40%	$140,250,000	$55,486,721.64	$139,399,501
2029	40%	$140,250,000	$55,446,944.92	$137,808,919
2030	40%	$140,250,000	$55,400,949.89	$136,100,276
2031	39%	$140,250,000	$55,358,896.91	$134,573,148
2032	39%	$140,250,000	$55,314,899.23	$132,982,267
2033	39%	$140,250,000	$55,272,758.06	$131,573,391
2034	39%	$140,250,000	$55,228,589.37	$130,227,892
			Total Undiscounted	$2,315,572,968
			7% Discount Rate	$1,100,206,522
			3% Discount Rate	$1,648,909,232

The remaining tank car options are considered analogously. To these benefits we other ECP benefits, such as business benefits, as presented in the Braking section of the RIA. We also add in costs for braking, classification, and routing in addition to the tank car costs to present comprehensive costs and benefits in the tables below.

CBC6: Table CBC6: Final Rule Costs and Benefits		
	7% Discount	**3% Discount**
Total Cost	$2,481,971,599	$3,094,967,161
LCE Benefits + Other ECP Benefits	$912,334,141	$1,365,368,402
LCE + Mean HCE Benefits + Other ECP	$1,355,211,969	$2,029,383,291
LCE + 95th Percentile HCE + Other ECP	$2,904,573,871	$4,352,370,139
Net Benefits, LCE+ Other ECP	-$1,569,637,459	-$1,729,598,759
Net Benefits, LCE + Mean HCE + Other ECP	-$1,126,759,630	-$1,065,583,870
Net Benefits, LCE + 95th Percentile HCE + Other ECP	$422,602,272	$1,257,402,977

The next table presents costs, benefits, and net benefits for the Option 3.

Table CBC 7: Option 3, Final Rule ECP Costs, and Benefits		
	7% Discount	**3% Discount**
Total Cost	$2,443,099,630	$3,036,632,698
LCE Benefits + Other ECP Benefits	$884,795,934	$1,324,967,696
LCE + Mean HCE Benefits + Other ECP	$1,308,953,852	$1,961,558,925
LCE + 95th Percentile HCE + Other ECP	$2,792,826,100	$4,188,606,958
Net Benefits, LCE+ Other ECP	-$1,558,303,696	-$1,711,665,002
Net Benefits, LCE + Mean HCE + Other ECP	-$1,134,145,777	-$1,075,073,773

Table CBC 7: Option 3, Final Rule ECP Costs, and Benefits		
Net Benefits, LCE + 95th Percentile HCE + Other ECP	$349,726,470	$1,151,974,260

The next table presents these figures for the Option 2 tank car.

Table CBC 8: Option 2, Final Rule ECP Costs, and Benefits		
	7% Discount	**3% Discount**
Total Cost	$3,150,153,815	$3,960,384,968
LCE Benefits + Other ECP Benefits	$995,160,213	$1,493,115,679
LCE + Mean HCE Benefits + Other ECP	$1,493,450,261	$2,242,883,389
LCE + 95th Percentile HCE + Other ECP	$3,236,666,034	$4,865,867,538
Net Benefits, LCE+ Other ECP	-$2,154,993,602	-$2,467,269,289
Net Benefits, LCE + Mean HCE + Other ECP	-$1,656,703,554	-$1,717,501,579
Net Benefits, LCE + 95th Percentile HCE + Other ECP	$86,512,219	$905,482,570

The following three tables present the same figures above except that instead of presenting the tank car options in combination with the final rule ECP mandate, the tank car options are combined with the other ECP option considered in this document.

First, we present the final rule tank car with the Alternative ECP braking option:

Table CBC 9: Final Rule Tank Car plus Alterative 1 ECP Costs and Benefits		
	7% Discount	**3% Discount**
Total Cost	$2,750,399,536	$3,453,193,619
LCE Benefits + Other ECP Benefits	$869,495,357	$1,313,388,944
LCE + Mean HCE Benefits + Other ECP	$1,317,541,782	$1,985,382,790
LCE + 95th Percentile HCE + Other ECP	$2,884,985,478	$4,336,283,185
Net Benefits, LCE+ Other ECP	-$1,880,904,179	-$2,139,804,675
Net Benefits, LCE + Mean HCE + Other ECP	-$1,432,857,754	-$1,467,810,829
Net Benefits, LCE + 95th Percentile HCE + Other ECP	$134,585,942	$883,089,566

Next, we present the Option 3 tank car with the alternative ECP braking option.

Table CBC 10: Option 3 Tank Car, Alternative 1 ECP Costs and Benefits		
	7% Discount	**3% Discount**
Total Cost	$2,711,527,567	$3,394,859,156
LCE Benefits + Other ECP Benefits	$842,139,570	$1,273,271,605
LCE + Mean HCE Benefits + Other	$1,271,586,410	$1,918,030,014

ECP		
LCE + 95th Percentile HCE + Other ECP	$2,773,961,401	$4,173,650,071
Net Benefits, LCE+ Other ECP	-$1,869,387,997	-$2,121,587,551
Net Benefits, LCE + Mean HCE + Other ECP	-$1,439,941,156	-$1,476,829,142
Net Benefits, LCE + 95th Percentile HCE + Other ECP	$62,433,834	$778,790,915

Finally, we present the Option 2 tank car with the alternative ECP braking option.

Table CBC 11: Option 2 Tank Car, Alternative 1 ECP Costs and Benefits

	7% Discount	3% Discount
Total Cost	$3,418,581,752	$4,318,611,426
LCE Benefits + Other ECP Benefits	$951,693,996	$1,440,145,047
LCE + Mean HCE Benefits + Other ECP	$1,454,737,493	$2,197,231,312
LCE + 95th Percentile HCE + Other ECP	$3,214,582,712	$4,845,818,662
Net Benefits, LCE+ Other ECP	-$2,466,887,756	-$2,878,466,380
Net Benefits, LCE + Mean HCE + Other ECP	-$1,963,844,259	-$2,121,380,115
Net Benefits, LCE + 95th Percentile HCE + Other ECP	-$203,999,041	$527,207,236

Based on the figures presented above, the Final Rule produces the highest net benefits/lowest net costs when compared to the other options under consideration. One option examined presents a more stringent tank car standard than that adopted by the final rule. Although this option produces higher benefits, it also comes at a higher cost, resulting in lower net benefits/higher net costs than the Final Rule. The less stringent option produces lower cost but commensurately lower benefits, and also produces lower net benefits/higher net costs than the Final Rule. The Final Rule appears to be the best compromise between enhanced safety and cost.

XI. Conclusions

Hazardous materials such as crude oil and ethanol are essential to the economy of the U.S. and the well-being of its people. These materials are an important part of the U.S. economy and have many manufacturing and other industrial applications. The need for these hazardous materials to support essential services means transportation of hazardous materials is unavoidable; rail transportation of hazardous materials in the United States is generally recognized to be a safe method of moving large quantities of hazardous materials over long distances.

PHMSA, in coordination with FRA, is requiring new operational requirements for HHFTs comprised of 20 or more tank car loads of a Class 3 flammable liquid in a continuous block or 35 or more tank car loads of a Class 3 flammable liquid across the entire train. This ensures that the

requirements are closely aligned with the risks posed by the operation of trains that are transporting large quantities of flammable liquids.

PHMSA is mandating improvements in tank car standards for HHFTs and revision of the general requirements for offerors to ensure proper classification and characterization of unrefined petroleum-based products. These new requirements are designed to lessen the frequency and consequences of derailments involving ethanol and crude oil, when moved as a HHFT. The growing reliance on trains to transport large volumes of flammable liquids poses a significant risk to life, property, and the environment. These significant risks have been highlighted by the recent derailments of trains carrying crude oil in Lynchburg, Virginia, Casselton, North Dakota, Aliceville, Alabama, and Lac-Mégantic, Quebec, Canada.

Shipments of flammable liquids in large volumes pose a risk of catastrophic consequences during transportation. In addition, both the number of shipments and accidents involving large flammable liquids has increased.

Consistent with the final rule, the following table provides the five (5) requirement areas considered in this analysis and their costs.

Table CBC12 shows the costs and benefits by affected section and rule provision over a 20-year period, discounted at a 7% rate. Table CBC12 also shows an explanation of the comprehensive benefits and costs (i.e., the combined effects of individual provisions), and the estimated benefits, costs, and net benefits of each amendment.

Please also note that, given the uncertainty associated with the risks of HHFT shipments, Table CBC12 contains a range of estimated benefits. The low-end of the range of estimated benefits estimates risk from 2015 to 2034, based on the U.S. safety record for crude oil and ethanol from 2006 to 2013, adjusting for the projected increase in shipment volume over the next 20 years. The upper end of the range of estimated benefits is the 95th percentile from the Monte Carlo simulation.

Table CBC12. 20 Year Costs and Benefits by Stand-Alone Proposed Regulatory Amendments 2015-2034[232]			
Affected Section[233]	**Provision**	**Benefits (7%)**	**Costs (7%)**
49 CFR 172.820	Rail Routing+	Cost effective if routing were to reduce risk of an incident by 0.41%	$8.8 million
49 CFR 173.41	Classification Plan	Cost effective if this requirement reduces risk by 1.29%	$18.9 million
49 CFR 174.310	Speed Restriction: 40 mph speed limit in HTUA*	$56 million – $242 million	$180 million
	Advanced Brake Signal Propagation Systems	$470.3 million - $1,1144 million	$492 million
49 CFR part 179	New Tank Car Construction and Existing Tank Car Retrofit	$450 million - $1,804 million	$1,782 million
Cumulative Total		$912 million-$2,905 million	$2,482 million
"*" indicates voluntary compliance regarding crude oil trains in high-threat urban areas (HTUA) "+" indicates voluntary actions that will be taken by shippers and railroads			

[232] All costs and benefits are in millions over 20 years, and are discounted to present value using a 7 percent rate.

[233] All affected sections of the Code of Federal Regulations (CFR) are in Title 49.

Appendix A: 2011 U.S. Business Statistics for Selected Industries that Ship Class 3 Hazardous Materials

NAICS CODE	NAICS DESCRIPTION	ENTERPRISE EMPLOYMENT SIZE	NUMBER OF FIRMS	NUMBER OF ESTABLISHMENTS	EMPLOYMENT
211111	Crude petroleum and natural gas extraction	1: Total	6,523	7,757	108,954
211111	Crude petroleum and natural gas extraction	2: 0-4	4,519	4,531	7,361
211111	Crude petroleum and natural gas extraction	3: 5-9	946	963	6,099
211111	Crude petroleum and natural gas extraction	4: 10-19	496	514	6,685
211111	Crude petroleum and natural gas extraction	5: <20	5,961	6,008	20,145
211111	Crude petroleum and natural gas extraction	6: 20-99	388	458	13,989
211111	Crude petroleum and natural gas extraction	7: 100-499	87	216	11,507
211111	Crude petroleum and natural gas extraction	8: <500	6,436	6,682	45,641
211111	Crude petroleum and natural gas extraction	9: 500+	87	1,075	63,313
211112	Natural gas liquid extraction	1: Total	136	338	10,005
211112	Natural gas liquid extraction	2: 0-4	58	58	0
211112	Natural gas liquid extraction	3: 5-9	11	11	67
211112	Natural gas liquid extraction	4: 10-19	6	6	0
211112	Natural gas liquid extraction	5: <20	75	75	250
211112	Natural gas liquid extraction	6: 20-99	15	16	536
211112	Natural gas liquid extraction	7: 100-499	9	21	947
211112	Natural gas liquid extraction	8: <500	99	112	1,733
211112	Natural gas liquid extraction	9: 500+	37	226	8,272
324191	Petroleum lubricating oil and grease manufacturing	1: Total	248	289	9,285
324191	Petroleum lubricating oil and grease manufacturing	2: 0-4	64	64	125
324191	Petroleum lubricating oil and grease manufacturing	3: 5-9	36	36	241
324191	Petroleum lubricating oil and grease manufacturing	4: 10-19	37	37	493
324191	Petroleum lubricating oil and grease manufacturing	5: <20	137	137	859
324191	Petroleum lubricating oil and grease manufacturing	6: 20-99	67	73	2,695
324191	Petroleum lubricating oil and grease manufacturing	7: 100-499	22	34	2,528
324191	Petroleum lubricating oil and grease manufacturing	8: <500	226	244	6,082
324191	Petroleum lubricating oil and grease manufacturing	9: 500+	22	45	3,203
325110	Petrochemical manufacturing	1: Total	43	60	10,398
325110	Petrochemical manufacturing	2: 0-4	14	14	0
325110	Petrochemical manufacturing	3: 5-9	2	2	0
325110	Petrochemical manufacturing	4: 10-19	1	1	0
325110	Petrochemical manufacturing	5: <20	17	17	49
325110	Petrochemical manufacturing	6: 20-99	4	4	260
325110	Petrochemical manufacturing	7: 100-499	5	5	433
325110	Petrochemical manufacturing	8: <500	26	26	742
325110	Petrochemical manufacturing	9: 500+	17	34	9,656
324110	Petroleum refineries	1: Total	198	296	63,150
324110	Petroleum refineries	2: 0-4	75	75	0
324110	Petroleum refineries	3: 5-9	23	23	148
324110	Petroleum refineries	4: 10-19	18	18	249
324110	Petroleum refineries	5: <20	116	116	490
324110	Petroleum refineries	6: 20-99	15	18	662
324110	Petroleum refineries	7: 100-499	23	25	2,766
324110	Petroleum refineries	8: <500	154	159	3,918
324110	Petroleum refineries	9: 500+	44	137	59,232
325192	Cyclic crude and intermediate manufacturing	1: Total	25	28	3,166
325192	Cyclic crude and intermediate manufacturing	2: 0-4	1	1	0
325192	Cyclic crude and intermediate manufacturing	3: 5-9	1	1	0
325192	Cyclic crude and intermediate manufacturing	4: 10-19	1	1	0
325192	Cyclic crude and intermediate manufacturing	5: <20	3	3	0
325192	Cyclic crude and intermediate manufacturing	6: 20-99	7	7	243
325192	Cyclic crude and intermediate manufacturing	7: 100-499	3	3	338
325192	Cyclic crude and intermediate manufacturing	8: <500	13	13	605
325192	Cyclic crude and intermediate manufacturing	9: 500+	12	15	0
325193	Ethyl alcohol manufacturing	1: Total	168	219	10,299
325193	Ethyl alcohol manufacturing	2: 0-4	19	19	30
325193	Ethyl alcohol manufacturing	3: 5-9	8	8	0
325193	Ethyl alcohol manufacturing	4: 10-19	12	13	175
325193	Ethyl alcohol manufacturing	5: <20	39	40	257
325193	Ethyl alcohol manufacturing	6: 20-99	97	99	4,038
325193	Ethyl alcohol manufacturing	7: 100-499	17	37	2,299
325193	Ethyl alcohol manufacturing	8: <500	153	176	6,594
325193	Ethyl alcohol manufacturing	9: 500+	15	43	3,705

Source: U.S. Census Bureau, Statistics of U.S. Businesses, 2011

Appendix B: Crude Oil/ Ethanol Derailment Accidents Research

Appendix B summarizes the impacts of recent accidents involving HHFTs of crude oil and ethanol. While not all accidents involving crude oil and ethanol release have significant consequences, these accidents indicate the potential harm from future releases. The following includes an accounting of the rail accidents involving crude oil and ethanol, including their location, a sample of major accidents including number of cars punctured, location of puncture, and amount of product released, and finally a list of literature examining the economic and social impacts of crude oil and ethanol spills.

Table B1: Mainline Derailments of Crude Oil and Ethanol from 2006-2013
Geographic locations of mainline crude oil and ethanol rail accidents in the United States (2006-2013)

Incident Date	Product	UN No.	Speed at Derailment (mph)	Cars Releasing	No. Main Line Incidents	Qty. Released per derailment	Unit of Measure	City	State or Province
4/22/2006	Ethanol	UN1268	5	1	1	9,000	LGA	CHILLICOTHE	OHIO
5/30/2006	Ethanol	UN1987	50	0	1	0	LGA	TRIBES HILL	NEW YORK
10/20/2006	Ethanol	UN1987	37	20	1	485,278	LGA	NEW BRIGHTON	PENNSYLVANIA
11/11/2006	Ethanol	UN1987	10	1	1	1,000	LGA	PORTAGE	INDIANA
11/22/2006	Ethanol	UN1987	24	7	1	24877	LGA	CAMBRIDGE	MINNESOTA
2006 Total				29cars	5 cars	520155	LGA		
6/30/2007	Ethanol	UN1987	20	1	1	29357	LGA	PLUMAS	CALIFORNIA
10/10/2007	Ethanol	UN1987	48	5	1	55200	LGA	PAINESVILLE	OHIO
12/28/2007	Ethanol	UN1987	23	2	1	16000	LGA	NEW FLORENCE	PENNSYLVANIA
2007 Total				8 cars	3cars	100557	LGA		
8/16/2008	Ethanol	UN1987	17	1	1	12,447	LGA	COUNCIL	NORTH CAROLINA
8/22/2008	Crude Oil	UN1267	19	5	1	80746	LGA	LUTHER	OKLAHOMA
12/7/2008	Crude Oil	UN1267	55	6	1	140	LGA	PAGE	NORTH DAKOTA
2008 Total				12cars	3cars	93333	LGA		
1/12/2009	Ethanol	UN1987	44	1	1	1	LGA	DEFIANCE	OHIO
3/8/2009	Ethanol	UN1987	10	2	1	85	LGA	JESUP	IOWA
5/28/2009	Ethanol	UN1987	18	1	1	100	LGA	GREEN MOUNTAIN	NORTH CAROLINA
6/19/2009	Ethanol	UN1987	19	13	1	232693	LGA	CHERRY VALLEY	ILLINOIS
7/23/2009	Ethanol	UN1987	11	1	1	174	LGA	MAX	NORTH DAKOTA
9/15/2009	Ethanol	UN1987	2	2	1	8204	LGA	KNOXVILLE	TENNESSEE

Table B1: Mainline Derailments of Crude Oil and Ethanol from 2006-2013
Geographic locations of mainline crude oil and ethanol rail accidents in the United States (2006-2013)

10/28/2009	Crude Oil	UN1267	30	1	1	1	LGA	LODI	OHIO
12/13/2009	Ethanol	UN1170	15	1	1	1	LGA	CARBONDALE	ILLINOIS
2009 Total				22	8	241259	LGA		
2/20/2010	Ethanol	UN1987	20	1	1	24175	LGA	KEENE	CALIFORNIA
3/11/2010	Ethanol	NA1987	10	1	1	5	LGA	WINDHAM	CONNECTICUT
4/19/2010	Ethanol	UN1987	41	8	1	57613	LGA	BRYAN	OHIO
2010 Total				10	3	81793	LGA		
1/8/2011	Ethanol	UN1987	5	0	1	0	LGA	ROANOKE	VIRGINIA
2/6/2011	Ethanol	UN1987	46	31	1	834840	LGA	ARCADIA	OHIO
5/4/2011	Ethanol	NA1987	24	1	1	28000	LGA	BURLINGTON	OREGON
7/6/2011	Ethanol	UN1987	28	1	1	1	LGA	MORRISTOWN	INDIANA
7/19/2011	Ethanol	UN1987	10	1	1	366	LGA	AURORA	SOUTH DAKOTA
10/7/2011	Ethanol	UN1987	34	10	1	143534	LGA	TISKILWA	ILLINOIS
2011 Total				44 cars	6 cars	1006741	LGA		
1/6/2012	Ethanol	UN1987	44	5	1	2.25	LGA	WESTVILLE	INDIANA
6/1/2012	Ethanol	UN1170	25	2	1	40099	LGA	OAKLAND CITY	INDIANA
7/11/2012	Ethanol	UN1987	23	3	1	53347	LGA	COLUMBUS	OHIO
8/5/2012	Ethanol	UN1987	23	12	1	245336	LGA	PLEVNA	MONTANA
11/30/2012	Ethanol	UN1987	8	1	1	1	LGA	PAULSBORO	NEW JERSEY
12/30/2012	Ethanol	UN1987	15	1	1	16000	LGA	MOUNT VERNON OUTLAND AIRPORT	ILLINOIS
2012 Total				24 cars	6 cars	354785	LGA		
3/27/2013	Crude Oil	UN1267	40	3	1	15000	LGA	PARKERS PRAIRIE	MINNESOTA
5/23/2013	Crude Oil	UN1267	23	0	1	0	LGA	BEAR CREEK	ALABAMA
7/17/2013	Ethanol	UN1170	28	1	1	1	LGA	BUFFALO	NEW YORK
10/21/2013	Crude Oil	UN1267	20	1	1	1	LGA	SMITHBORO	ILLINOIS
11/7/2013	Crude Oil	UN1267	39	25	1	455520	LGA	ALICEVILLE	ALABAMA

Table B1: Mainline Derailments of Crude Oil and Ethanol from 2006-2013
Geographic locations of mainline crude oil and ethanol rail accidents in the United States (2006-2013)

12/30/2013	Crude Oil	UN1267	42	18	1	474936	LGA	CASSELTON	NORTH DAKOTA
2013 Total				48 cars	6 cars	945458	LGA		
1/20/2014	Crude Oil	UN1267	7	0	1	0	LGA	PHILADELPHIA	PENNSYLVANIA
1/31/2014	Crude Oil	UN1267	45	4	1	90000	LGA	NEW AUGUSTA	MISSIPPI
2/11/2014	Ethanol	UN1987	10	1	1	25	LGA	JACKSONVILLE	FLORIDA
2/13/2014	Crude Oil	UN1267	31	4	1	10000	LGA	VANDERGRIFT	PENNSYLVANIA
4/30/2014	Crude Oil	UN1267	23	2	1	30000	LGA	LYNCHBURG	VIRGINIA
5/9/2014	Crude Oil	UN1267	9	1	1	7932	LGA	EVANS	COLORADO

Table B2: Major Crude Oil/Ethanol Train Accidents in the U.S. and Canada (2006-2014) used in tank car modeling

Incident	Date	Tank Cars Derailed	Lost Containment	Cars Punctured	Speed at Derailment	Puncture only breach	SE only breach	Material	Product loss	Shell Puncture	Top Head Puncture	Bottom Head Puncture	Top fittings damage	BOV Damage	Thermal Damage	CPC1232	CPC-1232 w/ jacket	legacy
LaSalle, CO	May-14	5	1	0	9	0	1	Crude Oil (unit)	<5,000	0	0	0	1	0	0	0	0	5
Lynchburg. VA	May-14	17	2	1	23	1	1	Crude Oil (unit)	30,000	1	0	0	1	0	0	13	0	4
Vandergrift, PA	Feb-13	21	4	1	30	1	3	Crude Oil, LPG	10,000	1	0	0	2	1	0	0	0	18
New Augusta, MS	Jan 2014	20	9	5	45	4	0	Crude Oil (unit)	90,000	1	1	3	0	0	0	0	13	0
Plaster Rock	Jan 2014	9	2	2	47 (EB)	2	0	LPG, Crude Oil	~30,000	0	1	1	0	1	0	1	2	2
Casselton, ND	Dec 2013	20	18	18	42	3	0	Crude Oil (unit)	476,436	13	3	4	10	3	3	0	0	
Aliceville, AL	Nov 2013	26	20	16	38	2	1	Crude Oil (unit)	350,000	12	4	9	18	0	4	0	0	
Lac-Mégantic	July 2013	63	59	55	65	-	-	Crude Oil (unit)	1,580,000	33	10	16	20	7	4	0	0	

Plevna, MT	Aug 2012	17	11	2	25	2	1	Ethanol	245,336	1	0	1	0	0	6	0	0	
Columbus, OH	July 2012	3	3	1	23	1	0	Ethanol	53,347	0	1	0	0	0	2	0	0	
Tiskilwa, IL	Oct 2011	10	7	4	34	2	0	Ethanol	143,534	2	0	3	3	1	3	0	0	
Arcadia, OH	Feb 2011	31	31	23	46	14	4	Ethanol (unit)	834,840	16	6	7	16	2	5	0	0	
Rockford, IL	June 2009	19	12	10	36	10	2	Ethanol (unit)	232,963	4	4	5	2	1	0	0	0	
Luther, OK	Aug 2008	8	8	2	19	3	4	Crude Oil		3			4		1			
Painesville, OH	Oct 2007	7	2	1	48	1	1	Ethanol	76,153	1	0	0	1	0	0	0	0	
New Brighton, PA	Oct 2006	23	19	11	37	5	7	Ethanol (unit)	485,278	5	3	6	14	0	1	0	0	

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Appendix C: Lac-Mégantic Accident Non-Fatalities Potential Damage Estimates

On July 6, 2013, a catastrophic railroad accident occurred in Lac-Mégantic, Quebec, Canada when an unattended freight train containing crude oil rolled down a descending grade and subsequently derailed. The derailment resulted in multiple releases and subsequent fires, which caused the confirmed deaths of forty-seven individuals. In addition, according to many news reports this derailment caused extensive damage to the town, the destruction of over 30 buildings and approximately half of the downtown area, a release of hazardous materials that would require clean-up costs, and the evacuation of approximately 2,000 people. Although the event took place in Canada, PHMSA believes it presents a unique data point that can be used to characterize the magnitude of a potential future catastrophic event that could occur in the U.S.

The costs of the Lac-Mégantic train accident are still being estimated as cleanup and reconstruction efforts continue and lawsuits and insurance cases still need to be resolved. Therefore, it probably won't be possible to obtain a final tally for several more years. PHMSA compiled different costs reported in the media, and have developed estimates of other costs on our own in order to produce and a very rough preliminary estimate of what we think the final cost of such an occurrence might be. These costs consist of property damage to the town, environmental and other cleanup costs, the costs associated with re-routed train traffic, evacuation and emergency response costs, and the value of the rail cars and oil that was lost. These costs exceed $450 million and include about $200 million in property damage and $200 million in environmental cleanup, as seen in the table below:

Inputs into Non-Fatalities Damages Estimates[234]

[234] Note: Estimates based on analysis of Waybill data, where products are sourced and where they go, and train routes to estimate diverted traffic volumes through Lac-Mégantic. The figures reflect the marginal increase in transportation costs. Network effects are assumed to be marginal given the low volume of trains on the particular track that runs through Lac-Mégantic.

Cost Item	Units	Number of Units	Cost per Unit	Total Cost	Notes and Sources
Evacuation	Person Days	8400	217	$1,822,800	1200 people at 3 days, 800 people at 6 days, exlcudes long-term living costs for people whose homes were damaged
Emergency Response	Person Hours	7200	50	$360,000	150 firefighters (http://newsinfo.inquirer.net/439937/at-least-80-missing-in-canada-train-blaze-firefighter), assume 48 hours per person, assume $50 per hour including benefits and overhead
Property Damage and Survivor assistance to town				$200,000,000	Bangor Daily News, Oct 14, 2013
Environmental Cleanup				$400,000,000	http://www.thestar.com/news/canada/2014/06/16/quebec_claims_400_million_for_lacmgantic_train_disaster.html
Loss of Tank Cars	Number	74	115,000	$8,510,000	Assume all tank cars unusable
Loss of Product	Barrels	44,982	92	$4,138,344	$85 per barrel for Bakken Crude + $7 for transportation (from waybill), 714 barrels per tank car, 63 cars destroyed
Delay/Reroute Crude from Bakken	Barrels	9,510,480	4.2	$39,944,016	74 cars per day: assuming large daily shipments to Irving refinery based on Dec 26 2012 Bloomberg News article "Irving Refinery Said to Get 90,000 Barrels a Day by Rail": http://www.bloomberg.com/news/2012-12-26/irving-refinery-said-to-get-90-000-barrels-a-day-by-rail.html; 714 barrels per car (AAR), 6 months since accident happened, 30 days per month, 4.2 dollar rail differential on crude shipped from Alberta vs Bakken (waybill). Within 6 days of the accident, Irving was already rerouting Bakken crude through Southern Maine and (Pan Am Railway) and on CN tracks (CBS News - New Brunswick, July 12). The total cost increase should not exceed $4.2 per carload as Irving would just switch to using Alberta oil instead of Bakken oil at that point.
Dealy/Reroute Lumber from New Brunswick	Carloads	1,500	1000	$1,500,000	Waybill, cost increase based on figure reported by Lumber shipper who cited $500-$1500 per carload increase (WLBZ2 News, Augusta Maine, July 31)
Dealy/Reroute Other products Canada to Maine	Carloads	2,000	1000	$2,000,000	Waybill, cost increase based on figure reported by Lumber shipper who cited $500-$1500 per carload increase (WLBZ2 News, Augusta Maine, July 31)
Total Costs to Date				$658,275,160	

Appendix D: HCE Model – Calculation of Population Density and Wetland Damages

Population Density Calculation

1) We selected appropriate records from the Confidential Surface Transportation Board 2012 Waybill Sample using Surface Transportation Commodity Codes "1311110" for crude oil and "28184" for ethanol.
2) We assigned selected fuel waybill records to a routable rail network (scale 1:100,000) based on railroad ownership, trackage rights, and historical route densities. We identified all crude and ethanol rail corridors within the United States. The resulting rail fuel network includes all originating, terminating, and intermediate stations (nodes) and all rail links traversed by fuel cars. The process identified 20,420 rail links totaling 36,500 railroad miles. Rail link length ranged from 0.005 to 25 miles, with average link length at 1.8 miles. Over 10,500 rail links are less than one-mile long.
3) The 2010 Census Block data provides GIS population data down to the block level and includes over 11 million records. A one-kilometer-wide buffer zone (1/2 kilometer on either side of the track) was imposed over the fuel rail network using GIS software. A half kilometer on either side was chosen to reflect the impact zone for the Lac-Mégantic incident.[235] Then the Census Blocks that overlap with that buffer zone are identified. Density was calculated for each Block by dividing population by the area, which yields the population per square km.
4) For Census Blocks that include an entire rail link, the population density of that Block was applied to the rail link. For rail links that include more than one Census Blocks, the population density along the rail link is taken as a weighted average of the population density of the Census Blocks—the weighting is for the proportion of the rail link's buffer zone area that each Census Block occupies.
5) For verifications, these results were compared to Census maps and 2006 Census Track Data.

[235] http://www.bloomberg.com/news/2013-07-06/train-carrying-crude-derails-in-quebec-town-sparking-explosions.html. This article reports that explosions and fires were concentrated in an area about one square kilometer, which indicates that a half-kilometer on either side of the track is a reasonable assumption. PHMSA used measurements taken with GIS of the blast area showing a radius of .37 km and a new diameter of .49 km with a significant portion of all the damage occurring on one side of the track. At the time of this analysis PHMSA does not have access to another tool such as georeferenced imagery to more accurately determine the blast area. Thus, PHMSA maintained that a half-kilometer on either side of the track is a reasonable assumption to reflect the impact zone.

Costs of Wetland Damages

With regards to wetlands, the majority of the cost documentation relates to the restoration costs of the impacted wetlands rather than just the cleanup costs. There was one report related to a 1973 oil spill that broke down cleanup costs, but more recent documentation of incidents, specifically in the post Oil Pollution Act of 1990 era, focus on restoration costs. Below is a list of examples of oil spills where damage to wetlands was significant and the damage was also documented in the damage assessment and settlement documents, and a table calculating the per gallon costs for wetland damages of each incident.

Incident Examples:

1. **Motor Vessel Westchester Grounding in 2000:** The vessel grounded along the Mississippi River, releasing approximately 500,000 gallons of crude oil. The responsible party did not pay the natural resource trustees for restoration of the impacted area, but rather took the projects on themselves and acquired contractors to complete the restoration projects. However, the responsible party did have to pay the federal and state government a total of $968,175 ($1,204,432 in 2014 dollars)[236] for the response costs incurred from the oil spill.

2. **Equinox Well Spill in 1998**: An oil well belonging to the Equinox Oil Company released approximately 63,000 gallons of oil into Lake Grande Ecaille and the Gulf of Mexico. As a result over 1,200 acres of wetlands in Louisiana were exposed to oil. In 2006, a settlement of $1.2 million ($1,365,867 in 2014 dollars)[237] was awarded to trustees of the damaged wetlands.

3. **The Apex Barge Spill in 1990**: A tanker vessel collided with the Apex tank barges, spilling approximately 694,000 gallons of partially refined crude. The spill impacted shorelines, birds, and marsh wetlands. In 1994 the trustees responsible for the natural resources that were damaged by the oil spill agreed on a settlement of $1.3 million dollars ($1,899,427 in 2014 dollars).[238] The settlement was used to fund four wetland restoration projects, which collectively developed 298 acres of new wetlands and marsh areas. This translates to a per acre restoration cost of $4,362 ($6,374 in 2014 dollars).

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[236] The settlement was finalized in 2003, therefor the cost estimates were converted using the GDP deflator, where deflator index for 2003 is 86.754.

[237] Cost estimates were converted using the GDP deflator, where deflator index for 2006 is 94.818.

[238] Cost estimates were converted using the GDP deflator, where the deflator index for 1994 is 73.865 and for 2014 it is 107.924 (US Dollar Implicit Price Deflators for Gross Domestic Product 1929-2014, 2009=100, BEA).

4. **The Zoe Colocotroni Spill in 1973**: Occurred 3 miles off the shore of Puerto Rico, spilling approximately 50,000 barrels of crude oil. Cost claims for the spill with regard to wetlands and wildlife were broken down as follows:

1) Direct cost of removing dead and dying mangrove trees and removing and replacing soiled sediments = $7.17 million ($29.35 in 2014 dollars)[239]
2) Direct cost of replanting 23 acres (where the mangrove trees were removed) = $0.56 million ($2.29 in 2014 dollars)
3) Direct cost of environmental damages for marine animals killed = $5.5 million ($22.51 in 2014 dollars)
4) Direct cost of a scientific evaluation/assessment of the long term effects of the environmental damages the spill created = $1.39 million ($5.69 in 2014 dollars)

The costs of the lost wildlife was estimated using a replacement cost method, which estimates the cost of replacing damaged wildlife (biota) based on the price lists from firms that supply labs and zoos with those plants/animals. However, it is noted that the replacement cost method may overestimate costs of wildlife because the costs paid by labs and zoos includes/accounts for transport and collection costs, and in most cases a level of profit for the supplier.

Table D1. Per gallon Cost Estimates of Wetland Oil Spills*

	Gallons Spilled	Costs (in 2014 $)	Cost per gallon (total spill volume)	Cost per gallon (50% spill volume)
Westchester	500,000	$1,204,432	$2.41	$4.82
Equinox	63,000	$1,365,867	$21.68	$43.36
Apex Barge	694,000	$1,899,427	$2.74	$5.47
Zoe Colocotroni	2,100,000	$54,150,000[240]	$25.79	$51.57

*Note: these are likely underestimating the cost per gallon, as not all gallons of the spills directly affect wetlands, but the estimate for the percent of oil from a spill that directly impacts wetlands is not known. However, in an analysis conducted by Mark Cohen, he breaks down the impact of deepwater oil spills on various natural resources and industries. The study estimates that for any given oil spill, on average 59.7 percent of the spill directly impacts the fishing industry (e.g. if 100 gallons were spilled, 59.7 gallons of oil would impact fishing), 51.5 percent of the spill directly impacts the water supply, 16.5 percent of the spill directly impacts bird wildlife in the

[239] Cost estimates were converted using the GDP deflator; where the deflator index for 1973 is 26.366.

[240] Does not include the long term effect costs, since those are not part of the cleanup costs.

area of the spill, and 0.7 percent of the spill directly impacts recreational activities[241]. Since his focus was on deepwater, wetlands are not one of the categories, however, it provides some evidence that we can assume approximately 50 percent of an oil spill would directly impact any one resource. Thus, the cost per incident is estimated at $14.7 million.[242]

NOAA's Habitat Equivalency Analysis (HEA) Model: a methodology established to determine the claims for damages to natural resources resulting from "discharges of oil, releases of hazardous substances, or physical injury." This model estimates the restoration costs of wetlands and other natural resources, rather than the explicit cleanup costs. Specifically, "In the case of a wetland damaged by an oil spill, an HEA would not necessarily estimate or value the damages to the wetlands or its services; instead, it calculates the natural resource service losses in discounted terms and then determines the scale of restoration projects needed to provide equal natural resource service gains in the future in discounted terms, thereby fully compensating the public for the natural resource injuries."[243]

It is noted that this method is now preferred over the replacement cost method, which was the common approach prior to the Oil Pollution Act of 1990. All oil spill events described above (except the Zoe Colocotroni spill, which occurred prior to 1990) used the HEA model to estimate restoration needs in the filed settlements.

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[241] Cohen, Mark. "The Costs and Benefits of Oil Spill Prevention and Enforcement." Journal of Environmental Economics and Management, 1986: 167-188.

[242] $14, 654931.5 = $58,619,726/4

[243] Barbier, Edward B. "Coastal Wetland Restoration and the Deepwater Horizon Oil Spill." Vanderbilt Law Review 64, no. 6 (2011): 1821-1849.

Appendix E: Cost Effectiveness Calculations and Methodologies

This document will describe the methodologies and calculation used to determine effectiveness of the proposed tank car and operational enhancements proposed in the final rule (HM-251). This document is divided into the following 5 sections.

Section 1: Calculation of most probable number of cars punctured based on tank car enhancements, brake system, and speed
Section 2: Intermediate specifications
Section 3: Thermal protection effectiveness
Section 4: Definition of "unit train"
Section 5: Equivalency of 20-car block and 35 cars throughout at consist

Section 1: Calculation of most probable number of cars punctured based on tank car enhancements, brake system, and speed

The benefit of the tank car enhancements, brake systems, and speed were evaluated using the calculated values for most probable number of tank cars derailed and punctured. Sharma & Associates, Inc. using a purpose built model calculated these values for FRA.[244] The parameters evaluated by the purpose built model are provided in Table AE1.

Table AE1: Parameters evaluated in the FRA's purpose built model

Parameter category	Subcategory	Description
Tank Car Enhancements	Legacy DOT-111	7/16" A516-70, non-jacketed
	DOT-111 (CPC1232)	7/16, TC-128, jacket, thermal protection, head shield
	DOT-117 (retrofit)	8/16", TC-128, jacket, thermal protection, head shield
	DOT-117 (new)	9/16", TC-128, jacket, thermal protection, head shield
Brake System	Conventional	End-of-train device
	TWEOT (for brake pipe induced emergency, TWEOT is equivalent to a distributed power locomotive at the rear of the train)	Two-way end-of-train device capable of initiating emergency from the rear based on signal from lead locomotive
	DP 2/3	Distributed power locomotive at a location at or near 2/3

[244] Sharma and Associates, Inc. Letter Report submitted to FRA March 2015.

Table AE1: Parameters evaluated in the FRA's purpose built model		
		back in the consist from the lead locomotive
	ECP (NBR 12%)	Electronically controlled pneumatic brakes with a set net brake ratio of 12%. This is the same brake ratio as Conventional, TWEOT and DP 2/3 systems in the purpose built model.
	ECP (NBR 14%)	Electronically controlled pneumatic brakes with a set net brake ratio of 14%. Maximum allowed by the AAR Standards and Recommended practices.
Speed	50 mph	Proposed maximum speed
	40 mph	Proposed maximum speed in High Threat Urban Areas
	30 mph	Speed in the range at which most of derailments under consideration in this rulemaking occurred.

The intent of the evaluation was to consider the effect of the location of derailment within the train on the resulting number of cars punctured. Accordingly, results of simulations of derailments at locations with 100 cars trailing, 50 cars trailing and 20 cars trailing were used to develop trend lines that allowed for consideration of a derailment at all location in the train (Figure 1). For this analysis a polynomial line fit was assumed.

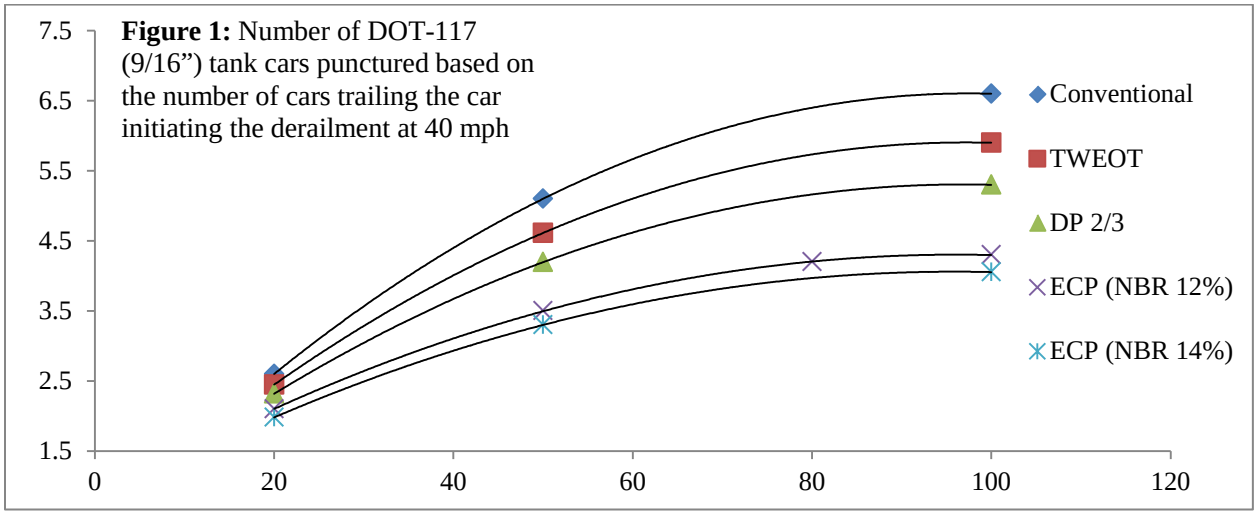


Figure 1: Number of DOT-117 (9/16") tank cars punctured based on the number of cars trailing the car initiating the derailment at 40 mph

Figure 2 summarizes the FRA data (Jan. 2000 - Nov 2014) of all freight train derailments. This will include all commodities, all car types and derailments from all causes indicating the location

of first car derailed in the first 100 cars of a train. The data provided below accounts for 96% of all the incidents. To facilitate calculations the data was organized into bins. Each bin is comprised of five sequential cars. For example, the first bin has cars 1-5, or cars with 100 (inclusive) through 96 cars trailing the point of derailment.

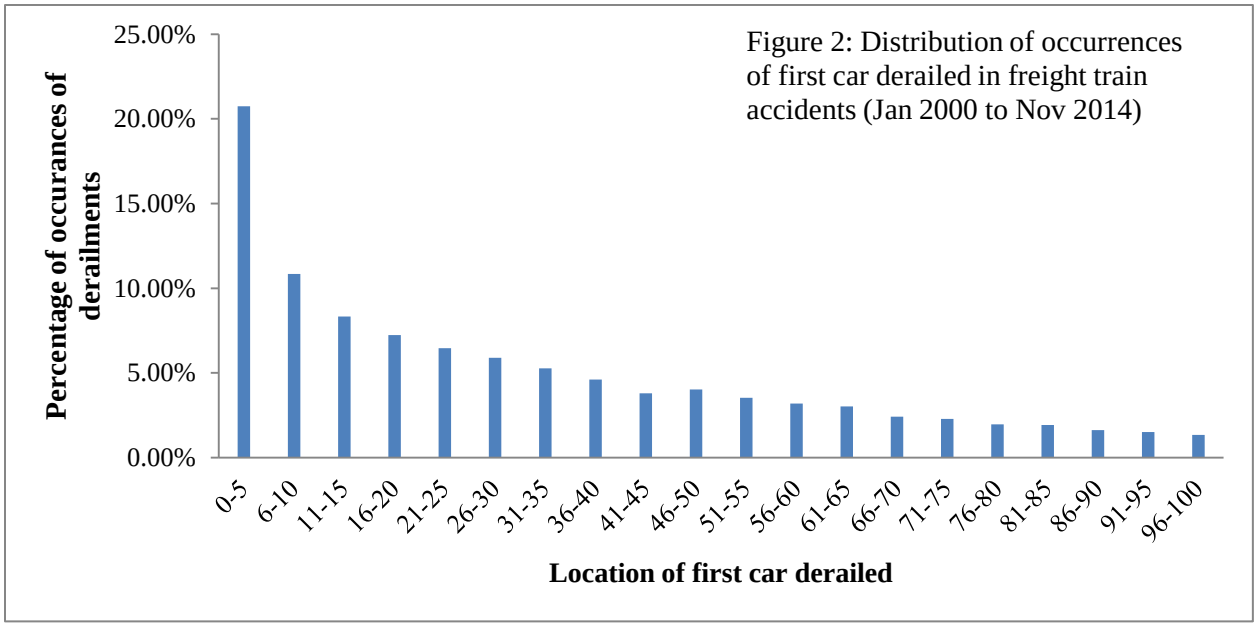


Figure 2: Distribution of occurrences of first car derailed in freight train accidents (Jan 2000 to Nov 2014)

The most probable number of cars punctured was calculated for the first and last car in each bin and the average was taken. An example of this calculation for the DOT-117 in a train equipped with a two-way end-of-train device and derailing at 40 mph is provided in Equation 1.

$$Puncture_a = ((-0.000585{x_l}^2 + 0.113x_l + 0.424) + (-0.000585{x_f}^2 + 0.113x_f + 0.424))/2 \quad (1)$$

Where x_f and x_l are the locations of the first and last cars in bin a.

The number of cars punctured for a particular bin is multiplied by the percentage of derailments that occur at locations within each bin. These values are summed for the 100 car train to provide the most likely number of DOT-117 tank cars punctured in a train equipped with EOT brakes that derails at 40 mph. These calculations are made according to Equation 2:

$$CP_{i,j,k} = \sum_{a-1}^{20} Puncture_a * P_a \quad (2)$$

Where $CP_{i,j,k,}$ is the calculated number of cars punctured, P_a is the probability of a derailment at a location within bin a (shown in Figure 2) . This number will be dependent on tank car specification (i), brake system (j), and initial speed (k). An example of the calculation for a DOT-117, TWEOT braking, at 40 mph is provided in Table AE2.

Table AE2: Example calculation of most probable number of car punctured (DOT-117, TWEOT brakes, 40 mph)					
			Polynomial Coefficients		
			-0.00058	0.113	0.424
Bin	Cars trailing point of derailment		Calculated per (1)	Calculated per (2)	
1	100	95	5.92	1.23	
2	95	90	5.91	0.64	
3	90	85	5.87	0.49	
4	85	80	5.80	0.42	
5	80	75	5.69	0.37	
6	75	70	5.56	0.33	
7	70	65	5.41	0.28	
8	65	60	5.22	0.24	
9	60	55	5.00	0.19	
10	55	50	4.75	0.19	
11	50	45	4.48	0.16	
12	45	40	4.18	0.13	
13	40	35	3.84	0.12	
14	35	30	3.48	0.08	
15	30	25	3.09	0.07	
16	25	20	2.67	0.05	
17	20	15	2.22	0.04	
18	15	10	1.74	0.03	
19	10	5	1.24	0.02	
20	5	0	0.70	0.01	
Most probable number of cars punctured				5.09	

A similar analysis was performed for each tank car specification, brake system and speed presented in the Braking section of the Final Rule, Table BR5:

Table AE3 shows the results of the analysis for the DOT-117 tank car.

Table AE3: Results of calculation to determine the most probable number of cars punctured for the DOT-117 considering different brake systems and speeds			
Tank Car	**Brake System**	**Speed (mph)**	**Most Probable number of cars punctured**
DOT-117	Conventional	30	2.81
		40	5.64
		50	7.82
	TWEOT	30	2.35
		40	5.09
		50	6.57
	DP2/3	30	2.43
		40	4.66

Table AE3: Results of calculation to determine the most probable number of cars punctured for the DOT-117 considering different brake systems and speeds			
		50	6.77
	ECP (12% NBR)	30	2.15
		40	3.78
		50	6.01
	ECP (14% NBR)	30	2.02
		40	3.57
		50	5.63

Section 2: Intermediate specifications

An intermediate specification is one that has not been specifically modelled in the Sharma simulations or related analyses. In order to determine the benefit of the tank cars proposed in the final rule, we needed to determine the most probable number of cars punctured for the intermediate specification tank car. The following describes the methodology used to develop those results.

Table AE4 provides the calculated number of tank car punctures for a variety of tank car configurations that include the enhancements considered in this final rule; grade of steel, additional thickness of shell and head, 11-gauge jacket, and ½" thick full height head shield. These calculations used the same force distribution of the 18 derailments described in the Sharma letter report. This analysis assumed a 40-mph derailment speed and the train being equipped with conventional and ECP brakes. The brake system under consideration bound the expected range of performance. This analysis is intended to determine the contribution of the enhancement on an individual basis, not the effectiveness of the brake system.

Table AE4 Results of analysis of alternative designs to determine the contribution of safety enhancements to the reduction in the most probable number of cars punctured			
100 Cars Behind POD at 40 mph		**Probable No. of Punctures**	
Tank Type		**Conventional Brakes**	**ECP Brakes**
Alternative 0	7/16" A516-70, no jacket, no head shield	13.7	9.8
Alternative 1	7/16" TC128, 11 gauge jacket, 1/2" full-height head shield	8.0	5.3
Alternative 1a	7/16" TC128, 11 gauge jacket, no head shield	12.2	8.6
Alternative 1b	7/16" TC128, no jacket, 1/2" full-height head shield	8.7	5.8
Alternative 1c	7/16" TC128, no jacket, no head shield	12.9	9.2
Alternative 3	9/16" TC128, 11 gauge jacket, 1/2" full-height head shield	6.6	4.3
Alternative 3a	9/16" TC128, 11 gauge jacket, no head shield	10.0	6.8
Alternative 3b	9/16" TC128, no jacket, 1/2" full-height head shield	7.2	4.8

Alternative 3c	9/16" TC128, no jacket, no head shield	10.6	7.3

Table AE5 indicates the contribution of each enhancement to the reduction in the number of punctures to tank cars involved in the derailments specified above. The calculated number of cars punctured for each of the Alternatives in Table AE4 was then used to calculate the reduction attributed to each enhancement.

The values in Table AE5 were calculated as follows using the values from Table AE4. Alternatives 0 and 1 are constructed of different steel. The contribution of the steel (C_s) was calculated according to (3).

$$C_s = P_b - P_{1c} \quad (3)$$

Where P_b is the most likely number of car punctured for the Alternative 0 in Table AE4 and P_{1c} is the most likely number of cars punctured in Alternative 1c in Table AE4.

The contribution of the jacket and head shield ($C_{J/HS}$), head shield (C_{HS}), and jacket (C_J) for the 7/16" tank operating with conventional brakes were calculated per (4), (5), and (6).

$$C_{J/HS} = P_b - P_1 - C_s \ (4)$$

$$C_{HS} = P_b - P_{1b} - C_s \ (5)$$

$$C_J = P_b - P_{1a} - C_s \ (6)$$

Where P_1 is the most likely number of cars punctured for Alternative 1, P_{1b} is the most likely number of cars punctured in Alternative 1b, and P_{1a} is the most likely number of cars punctured in Alternative 1a in Table AE4. All of the other (rounded) values in were calculated in a similar manner.

Table AE5: Contribution of enhancements to the reduction in the calculated number of cars punctured at 40 mph

	Tank Component	Likely % Reduction in No. of Punctures	
		Conventional Brakes	ECP Brakes
7/16" tank	jacket and full height head shield	4.9	3.9
	head shield	4.2	3.3
	jacket	0.7	0.5
	TC128B over A516-70	0.8	0.6
9/16" tank	jacket and head shield	4.0	3.0
	head shield	3.4	2.5
	jacket	0.6	0.5
	TC128B over A516-70	0.8	0.6
	from 7/16" to 9/16", TC128B	2.3	1.9

Table AE6 indicates the percent reduction in number of cars punctured for each enhancement. The percentages were used to calculate both the benefits of adding enhancement to a legacy DOT-111 specification car and removing enhancements from the other car specifications indicated in Table BR5:

Table AE6: Relative reduction in the number of cars punctured for individual tank car enhancements in 40-mph derailments

	Tank component	Conventional Brakes	ECP Brakes
7/16" tank	puncture reduction of Alternative 1 compared to Alternative 0	5.7	4.5
	head shield	Overall Percent Reduction	
		74%	73%
	Jacket	12%	11%
	stronger material, TC128B over A516-70	14%	13%
9/16" tank	puncture reduction of Alternative 3 compared to Alternative 0	7.1	5.5
	head shield	Overall Percent Reduction	
		48%	45%
	Jacket	8%	9%
	stronger material, TC128B over A516-70	11%	11%
	thicker tank wall: from 7/16" to 9/16", TC128B	32%	35%

For the purpose of an analysis the values for the half-inch thick shell is the average of 7/16” and the 9/16” values. To date only the specifications as outlined in Table BR5 have been considered in the benefits analysis. These values were used to calculate the benefits of the DOT-117 (new and retrofit) to a variety of existing cars.

The final rule proposes the DOT-117 (both retrofit and new) as indicated in Table BR5:

The effectiveness of these tank cars was calculated relative to four existing tank car specifications described in Table AE7.

Table AE7: Existing Tank Car Specifications

Tank Car Specification	Shell Material	Shell/Head Thickness	Jacket	Head Shield
DOT111	TC-128	7/16"	no jacket	no HS
CPC1232	TC-128	8/16"	no jacket	Half
Jacketed DOT111	TC-128	7/16"	jacket	no HS
Jacketed CPC1232	TC-128	7/16"	jacket	Full

The intermediate specifications include the DOT-111 constructed to the CPC-1232 Non-jacketed standard (equipped with a half-height head shield) and a legacy Jacketed DOT-111 (constructed of TC-128) (Table AE8, line 1). In order to calculate the benefit of the proposed tank car specifications (new and retrofit) relative to the intermediate specification, the most probable number of intermediate standard tank cars punctured was calculated as follows.

1) The base car is Alternative 0 in Table AE4 . These calculations of punctures of intermediate specification tank cars are relative to Alternative 0 (Table AE8, line 2 and 3).

2) Determine the most probable number of cars punctured for a tank car specification that has the same shell thickness as the intermediate specification car but also has all of the safety enhancements (high grade steel, jacket, and head shield). This will be referred to Base 2 car (Table AE8, lines 4 and 5).

3) The difference in the number of cars punctured is a result of the differences in the values of between the Base and Base 2 car (Table AE8, line 6).

4) Take account of the differences between the features of Base 2 car and the intermediate specification car (Table AE8, lines 8-12). These will be the steel specification and/or jacket and/or head shield. These features correlate to a respective contribution indicated in Table 4 for 7/16" and 9/16" thick tank cars. As indicated above the values for the 8/16" car are the average of the values indicated in Table AE7. The sum of the contribution of features (Table AE8, line 12) is multiplied by the difference in the cars punctured between the Base Car and Base Car 2 (Table AE8, line 6). This value (Table AE8, line13) is added to Base Car 2 to give the number of cars punctured of the intermediate specification car (Table AE8, line 14).

Table AE8: Calculation Summary			
1	Intermediate car	CPC-1232 (1/2 HS)	DOT-111(J)
2	Base car	DOT-111 legacy	DOT-111 legacy
3	Cars punctured	10.45	10.45
4	Base Car 2	CPC1232 (TC128, 8/16", J, HS)	CPC-1232 (TC128, 7/16", J, HS)
5	Cars Punctured	6.17	6.68
6	Difference in cars punctured	4.67	4.16
7	Features removed from Base Car 2		
8	Head shield	0.31 (1/2 HS Contribution)[245]	0.56 (1/4 HS Contribution)[246]

[245] The contribution of a half-height head shield is assumed to be half that of a full height head shield. This is based on derailment data which indicates that the head punctures are equally distributed between top and bottom halve of the tank head.

Table AE8: Calculation Summary			
9	jacket	0.1	0
10	Material	0	0
11	Thickness	0	0
12	Total	0.41	0.56
13	Adjustment of cars punctures	1.91	2.31
14	Corrected cars punctured	8.08	8.99

Using the calculated value of the most probable number of cars punctured for the intermediate specification tank cars as well as those explicitly modeled the effectiveness of the proposed cars relative to the existing cars ($E_{p/e}$) were calculated per (7).

$$E_{p/e} = 1 - \frac{CP_{i,j,k}}{CP_{i,j,k}} \quad (7)$$

The results are summarized in Table AE9.

Table AE9: Effectiveness regarding puncture resistance of proposed cars relative to existing specifications equipped with TWEOT and operating at 40 mph.		
	Cars punctured	**Effectiveness**
DOT-117 (new)	5.66	0
DOT-111	10.45	0.448
CPC-1232	8.08	0.299
DOT-111 (J)	8.99	0.370
CPC-1232 (J)	6.17	0.152
DOT-117 (retrofit)	6.17	0
DOT-111	10.45	0.398
CPC-1232	8.08	0.236
DOT-111 (J)	8.99	0.314
CPC-1232 (J)	6.17	0

Section 3: 100-Minute Thermal Protection[247]

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[246] The contribution of the jacket head is assumed to be a quarter of the full height head shield. This is based on the jacket head being a quarter of the thickness of the head shield.

[247] Thermal protection prevents release of lading from anywhere on the tank other than the pressure relieve device during exposure to a 100 minute pool fire or 30-minute torch fire.

The benefit of thermal protection is prevention of the thermal tear and high-energy (separation) events.[248] It is assumed the thermal protection system required will prevent these events. In other words a thermal protection system will basically provide 100% benefit for 100 minutes.[249] However, the benefit is only realized in derailments in which a portion of the cars does not lose containment in the derailment and which involve fire. This is a small percentage of the cars. Accordingly, the portion of derailed cars benefiting from thermal protection (P_{TP}) is calculated using (8).

$$P_{TP} = \left(\frac{Incident\ involving\ fire}{total\ incidents}\right) \times \left(\frac{no\ loss\ of\ containment}{total\ car\ involved}\right) \times \left(\frac{cars\ with\ thermal\ damage}{cars\ derailing\ no\ loss\ of\ containment}\right) \quad (8)$$

The data used for this calculation is provided in Table AE10. The calculated value of 3.36 is applied to the number of cars derailed but not punctured.

Table AE10: Data Related to Thermal Damage	
Events (Crude oil/EtOH)	46
Events involving fire	13
Cars involved	244
Cars not losing containment	81
Cars with thermal damage	29

The benefit of the thermal protection was allied to the overall tank car benefits by multiplying the effectiveness of the thermal protection, weighted by the expected portion of cares that could be affected, by the difference between the cars derailed and the cars punctured per (9).

$$Benefit\ of\ TP = (Cars\ derailed - cars\ punctured) \times P_{TP} \quad (9)$$

[248] A thermal tear is typically a longitudinal failure that occurs in the portion of the shell surrounding the vapor space of the tank following exposure of the tank to pool fire conditions. The tank shell fails when the pressure in the tank (and resulting tensile or hoop stress) exceeds the tensile strength of the shell material that is diminishing with time of exposure to the pool fire. The length of thermal tears measured during FRA investigations ranged from 2-16 feet. The length of the tear may be a function of the volume of vapor escaping through the failure, flaws in the shell material, and the existence of crack arresters such as welds or stronger, non-heat effected steel.

A separation occurs when a thermal tear propagates circumferentially from each end of the tear and result in the tank completely or nearly fragmenting into multiple pieces.

[249] The 100 minute threshold achieves to things. First, based on research in support of HM-144 the contents of a tank car loaded with LPG and exposed to pool fire condition will be evacuated through the pressure relieve valve in 100 minutes. As such, when a breach of the tank occurs (after 100 minutes) resulting from exposure to the fire the release will have limited energy. Second, 100 minutes is time for first responders to assess the situation and initiate evacuations.

The number of cars derailed was calculated in a manner similar to that used to calculate the number of cars punctured above. These values are independent of tank car specification. The results are provided in Table AE11.

The calculated vales were used in (9).

Table AE1: Most probable number of cars derailed based on initial speed and brake system			
Brakes system	**30 mph**	**40 mph**	**50 mph**
Conventional	14.89	22.90	28.53
TWEOT	14.04	22.11	28.05
DP 2/3	13.21	20.30	26.77
ECP (12% NBR)	12.25	19.08	24.50

This value, *Benefit of TP*, represents the derailed cars that do not lose containment when exposed to pool fire conditions. This number was added to the value of the number of cars punctured in a derailment to tank cars that do not have thermal protection to give the total number of cars losing containment in a derailment.

The benefit of a particular tank car, brake system and initial speed relative to another was calculated in accordance with (10).

$$Benefit_{u/v} = 1 - \frac{LC_{i,j,k}}{LC_{i,j,k}} \quad (10)$$

Where $LC_{i,j,k}$ is the number of cars losing containment (puncture and thermal damage) based on tank car specification (i), brake system (j), and initial train speed (k). The calculations are summarized in Table 12.

Table AE12: Calculation of effectiveness of puncture resistance and thermal protection of existing cars[250] relative to proposed cars equipped with TWEOT operating at 40 mph			
Tank Car Specification	**Cars punctured**	**Total cars loosing containment per (9)**	**Effectiveness**
DOT-117 (new)	5.66	5.66	0
DOT-111	10.45	11.19	0.494
CPC-1232	8.08	8.82	0.358
DOT-111 (J)	8.99	9.73	0.418
CPC-1232 (J)	6.17	6.91	0.181
DOT-117 (retrofit)	6.17	5.66	0
DOT-111	10.45	11.19	0.494

[250] It is assumed that none of the existing cars are equipped with thermal protection.

CPC-1232	8.08	8.82	0.358
DOT-111 (J)	8.99	9.73	0.418
CPC-1232 (J)	6.17	6.91	0.181

Section 4: Definition (length) of a unit train

Polynomial fits to the output from the simulations for 100-, 50- and 20-car trains and for each brake system under evaluation (conventional, TWEOT, DP at 2/3 back in the train, and ECP brakes) were developed. The polynomial fit was used to predict probable number of cars derailed and the number of cars punctured if a derailment occurred at each car location in the train.

The predicted number of cars punctured in a derailment originating at each location in the train was calculated using (11).

$$Puncture_i = (-.000142{x_i}^2 + 0.0753x_i + 1.49) \quad (11)$$

Where x_i is the locations of the car in the train. An example of the calculation for a 100 car train equipped with ECP (15 net brake ratio) operating at a maximum speed of 50 mph is provided in Table AE13.

Following equation (2) the predicted number is weighted by multiplying it by the percentage of derailments at each location in a 100-car train, in order to account for derailment location throughout a train. The scaled number of cars punctured for each location in the train is summed (from car 1 to car 100) to provide a predicted number of cars punctured for a 100-car unit train (Table AE13).

Table AE13: Example calculation to determine the most probable number of cars derailed throughout a train equipped with ECP (12% net brake ratio) and operating at 50 mph

				Coefficients used in (11)		
				-0.000142	0.0753	1.49
Location	Cars trailing	Occurrences of derailment	% of total	Cars punctured	Scaled number of cars punctured	Cumulative
1	99	1254	0.09	7.55	0.66	0.66
2	98	455	0.03	7.51	0.24	0.89
3	97	522	0.04	7.46	0.27	1.16
4	96	412	0.03	7.41	0.21	1.37
5	95	354	0.02	7.36	0.18	1.55
6	94	350	0.02	7.31	0.18	1.73
7	93	324	0.02	7.26	0.16	1.89
8	92	320	0.02	7.22	0.16	2.05
9	91	285	0.02	7.17	0.14	2.19
10	90	286	0.02	7.12	0.14	2.34
Rows 11-98 deleted						

99	1	31	0.00	1.57	0.00	5.96
100	0	31	0.00	1.49	0.00	5.96

We assert that the acceptable risk is a 100-car unit train made up of DOT-117 tank cars (9/16", jacket, head shield, and thermal protection) operating ECP brake mode with a 12-percent-net braking ratio moving at 50 mph. Similar calculations were performed for TWEOT[251] (current practice representing both two-way end-of-train devices and distributed power at the rear of the train) and ECP.

The calculated number of cars punctured in a train operating in ECP mode was 5.96. The length of the train operating in TWEOT mode with the same number of cars punctured was 64 cars. This means that a 64-car train operating in TWEOT mode presents the same risk as a 100-car train operating in ECP mode. A 65-car train in TWEOT poses a greater risk. Accordingly, the threshold can be set so that a train with 65 or more cars containing a flammable liquid must be equipped with ECP brakes and operated in ECP mode.

The largest incremental benefit of this requirement was calculated by subtracting the number of cars punctured in the TWEOT train from the ECP train. The calculated difference was 0.42 cars at 50 mph and 1.31 at 40 mph. It makes sense that the benefits of a brake system with faster brake signal propagation would have higher benefits at lower speeds. For the faster propagation system the brakes are fully applied for a longer time period. As the speed of the train at the time of derailment decreases, the time of full application is a greater percentage of the entire derailment time. This is particularly relevant because the average speed of derailment for the trains considered in this rule is 24.6 mph. In addition, the results presented in this RIA are based on ECP with a net brake ratio of 12 percent. The current AAR standards for ECP brakes allow that ratio to be as high as 14 percent. At that ratio the benefits increase to 0.79 for 50 mph and 1.52 for 40 mph.

Section 5: Equivalency of risk: 20-car block and 35 cars in manifest train

A proposed definition of a HHFT was 20 cars in a block or 35 throughout a train. We assert that the 20-car block represents the acceptable risk for a manifest train. This section describes how we determined the number of tank cars distributed randomly throughout a train that would have the equivalent level of risk to a 20-car block of tank cars.

To perform the calculations the following assumptions were made.

- Data regarding the first car derailed in freight trains provided in Table AE14 was used.
- Assumed a 100-car train

[251] TWEOT is a device that monitors the train line (brake pipe) pressure that is capable of receiving a signal from the lead locomotive and initiating an emergency brake application at the rear of the train.

- Assumed 20 cars derailed

The first step was calculating the risk of a derailment of a train comprised of a single, 20-car block of tank cars loaded with flammable liquids. In order to simplify the calculations, twenty bins of five cars each were created to represent an entire 100-car train. The first car of the 20-car block was placed at the first car of each bin. The 20-car block spanned four consecutive bins. The probability of a derailment at any of the locations within a particular block was calculated using (12).

$$P_m = \sum_{x=z}^{n+4} p_x \quad (12)$$

Where P_m is the probability of a derailment in Block m, p_x is the probability of a derailment at location x, and z is the location within the train of the cars in Block m.

$$P_{FL} = \sum_{m=i}^{i+3} P_m \times 20 \times \left(\frac{4-(m-i)}{4}\right) \quad (13)$$

Where P_{FL} is the probability of a tank car containing a flammable liquid derails, m is the block identifier, i is the initial block in the set of 20 cars that derail. Table AE14 provides the result of the calculation. The column on the right provides the calculated number of cars derailed. The largest number is from a block of cars located at the front of the train. Based on the probability distribution of location of first car derailed, the probable number of cars derailed is 6.5.

Table AE14: Number of cars derailed from a 20-car block based on location of first car in block

Bins	# of incidents	% of total	Block	First	Last	Derailed
0-5	2997	20.74%	1	1	20	6.50
6-10	1565	10.83%	2	6	25	4.13
11-15	1204	8.33%	3	11	30	3.41
16-20	1045	7.23%	4	16	35	3.02
21-25	932	6.45%	5	21	40	2.71
26-30	850	5.88%	6	26	45	2.42
31-35	761	5.27%	7	31	50	2.15
36-40	666	4.61%	8	36	55	1.91
41-45	549	3.80%	9	41	60	1.73
46-50	582	4.03%	10	46	65	1.67
51-55	509	3.52%	11	51	70	1.49
56-60	461	3.19%	12	56	75	1.34
61-65	437	3.02%	13	61	80	1.20
66-70	350	2.42%	14	66	85	1.03
71-75	331	2.29%	15	71	90	0.95
76-80	284	1.97%	16	76	95	0.85
81-85	278	1.92%	17	81	100	0.78
86-90	234	1.62%	18	86	100	0.42
91-95	218	1.51%	19	91	100	0.19
96-100	194	1.34%	20	96	100	0.05

A slightly different set of calculations were performed to determine the number of cars derailed in a manifest trains with tank car containing flammable liquid throughout the train. The same

five-car blocks were established to facilitate the calculations. A unique number generator was developed to list non-repeating numbers between 0 and 100. Numbers 1-35 were designated as representing tank car transporting flammable liquids. Once again, a 20-car derailment at the first car of each 5-car bock was assumed. The numbers of cars (identified as 1-35) were counted for each 20-car derailment occurring at each of the blocks in the train. For example, after refreshing the unique number (with numbers 1-35 highlighted), the number of highlighted cars in the twenty cars after each point of derailment was counted. For each block (point of derailment) the number of flammable liquid cars in the trailing 20 cars was recorded. This was repeated five times for 35 flammable liquid cars in the train and five times for both 40 and 45 cars in the train. The probability of a flammable liquid car derailed was calculated using (26).

$$P_{FL} = \sum_{i=1}^{20} P_{d\,(i)} \times N_i \quad (14)$$

Where P_d is the probability of a derailment initiating in the ith block, N_i is the number of flammable liquid cars counted in the 20 cars following the point of derailment. The results are summarized in Table AE15.

Table AE15: Results of calculations for manifest trains

Train	Flammable liquid cars derailed
20-car block (head end)	6.5
35 cars	6.32
40 cars	8.81
45 cars	8.66

Appendix F: Count Model for Low Consequence Events

Many historical models of oil spills develop probabilistic estimates of oil spill occurrence. Frequently, researchers have modeled spill occurrence as a Poisson process.[252,253,254] In these models, a stochastic process *N(t)* is a counting process if *N(t)* represents the total number of events that have occurred up to time *t*. These models generally model spills as a function of oil handled, or similar variables such as number of trips.

Instead of spills we are modelling derailments that can lead to spills. To do so, we also employ a count model. We can use these models when the dependent variable (y) takes integer values that represent the number of events that occur. In these cases, the dependent variable assumes discrete values, but is not a categorical value. Classic examples include the number of accidents on a pipeline. In the pipeline case, an explanatory variable could be the amount of product shipped. In such a case, a Poisson regression model would be appropriate.[255] This, of course, is similar to what we are trying to model here.

With a Poisson model, the explanatory variables ($Y_1, Y_2, \ldots, Y_n$) have independent Poisson distributions with parameters $\lambda_1, \lambda_2, \ldots, \lambda_n$, respectively.

$$\text{Prob}(Y_i = r) = \exp(-\lambda_i)\,[(\lambda_i)^r / y_i]$$

$$\ln \lambda_i = \beta_0 + \sum \beta_j X_{ij}$$

With Poisson models, the conditional variance is equal to the mean. This is not always true in actual data so it can limit the usefulness somewhat. The usefulness may also be limited if process does not have independent increments (i.e., independence of past events). This violation would occur if a derailment event were not independent of a prior derailment; however, this does not appear to be the case here. To measure for over-dispersion between the variance and the mean,

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[252] Smith RA, Slack JR, Wyant T, Lanfear KJ. The Oil Spill Risk Analysis Model of the US Geological Survey. US Geological Survey Professional, 1982, Paper 1227

[253] Anderson CM, LaBelle RP. Estimated Occurrence Rates for Analysis of Accidental Oil Spills on the US Outer Continental Shelf. *Oil & Chemical Pollution* 1990; 6:21–35.

[254] Homan A, Steiner, T. OPA 90's Impact at Reducing Oil Spills, *Marine Policy* 2008; 711-718

[255] Maddala GS. *Limited-dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press; 1989.

we use the Wooldridge test.[256] The test is a regression with the fitted values of y_i as the independent variable on es_i - 1 (the squared standardized residuals - 1). A significant t-statistic suggests over-dispersion and the value of the coefficient is an estimate of the necessary adjustment for it using an alternate Count Model framework (Negative Binomial). Otherwise, the Poisson specification is fine.

Data

We used actual historical data (1995-2013) from the Surface Transportation Board's (STB) Waybill Sample to derive total annual carloads of ethanol and crude (for more information on this data source see http://www.stb.dot.gov/stb/industry/econ_waybill.html). As discussed earlier in the RIA, the STB collects cargo waybill data under the requirement that all U.S. railroads that terminate more than 4,500 revenue carloads submit a yearly sample of terminated waybills. This data provides an indication of the annual volume of freight rail traffic in ethanol and crude.

We used available rail accident and incident reports from FRA Form 6180.54 (Rail Equipment Accident/Incident Report) and PHMSA Form 5800.1 (Hazardous Materials Incident Report), to derive total annual derailments from 2000-2013 (for more information on data submitted by these forms see http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Forms.aspx and http://www.phmsa.dot.gov/hazmat/incident-report). Rail carriers are required to report accidents that occur on the following types of track: main, yard, siding and industry. As previously discussed in the RIA, we only used main and siding accidents and incidents involving ethanol and crude given the scope of the rule.

Results

We ran a Poisson count model where the annual number of derailments of crude and ethanol trains (DRCR) is a function of a constant and the total number of crude and ethanol carloads in that year (CLCR). We would expect that derailments are an increasing function of carloads shipped. Due to data limitations in earlier years, we only have data available for derailments from 2000-2013. We ran the model using EVIEWS7 statistical software. The results are below.

Dependent Variable: DRCR
Method: ML/QML - Poisson Count (Quadratic hill climbing)
Date: 02/03/15 Time: 17:22
Sample: 2000 2013
Included observations: 14
Convergence achieved after 7 iterations

[256] Wooldridge JM. Quasi-likelihood Methods for Count data. In: Pesaran MH, Schmidt P, editors. *Handbook of Applied Econometrics*, vol. 2. Oxford: Blackwell; 1997 p. 352–406.

GLM Robust Standard Errors & Covariance
Variance factor estimate = 0.858061802535
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.159386	0.193635	5.987494	0.0000
CLCR	9.42E-07	4.64E-07	2.029572	0.0424

R-squared	0.257159	Mean dependent var	4.214286
Adjusted R-squared	0.195256	S.D. dependent var	2.044827
S.E. of regression	1.834364	Akaike info criterion	4.241095
Sum squared resid	40.37871	Schwarz criterion	4.332389
Log likelihood	-27.68767	Hannan-Quinn criter.	4.232644
Restr. log likelihood	-29.36192	LR statistic	3.348502
Avg. log likelihood	-1.977691	Prob(LR statistic)	0.067266

As expected, the coefficient for carloads shipped is positive. It is also significant at the 95 percent level of confidence. The R^2 for the model was about .26 but more importantly the LR statistic was significant at a 90 percent level of confidence (nearly 95) indicating the model as a whole had adequate explanatory power. We also ran a comparison between the actual number of derailments and the forecast number of derailments ("Fitted") during the estimation period (2000-2013). The table below shows the results. With the exception of certain outlier years on both the high and the low end (e.g. 2002 and 2009) the model did a reasonable job of predicting the number of derailments in the estimation period. The model also did not have a systematic bias in over or under predicting derailments as forecast errors residuals ("Residual") are fairly evenly split between positive residuals (under predict) or negative residuals (over predict). To ensure that there was not an over-dispersion issue with the Poisson specification, we ran a Wooldridge test (see Model). The results showed that the coefficient for the fitted values of y_i was not statistically significant and as such the use of the Poisson was fine. The biggest issue with the model is the limited sample size of 14 years followed by lack of additional explanatory variables; the latter which might be picked up in the constant term.

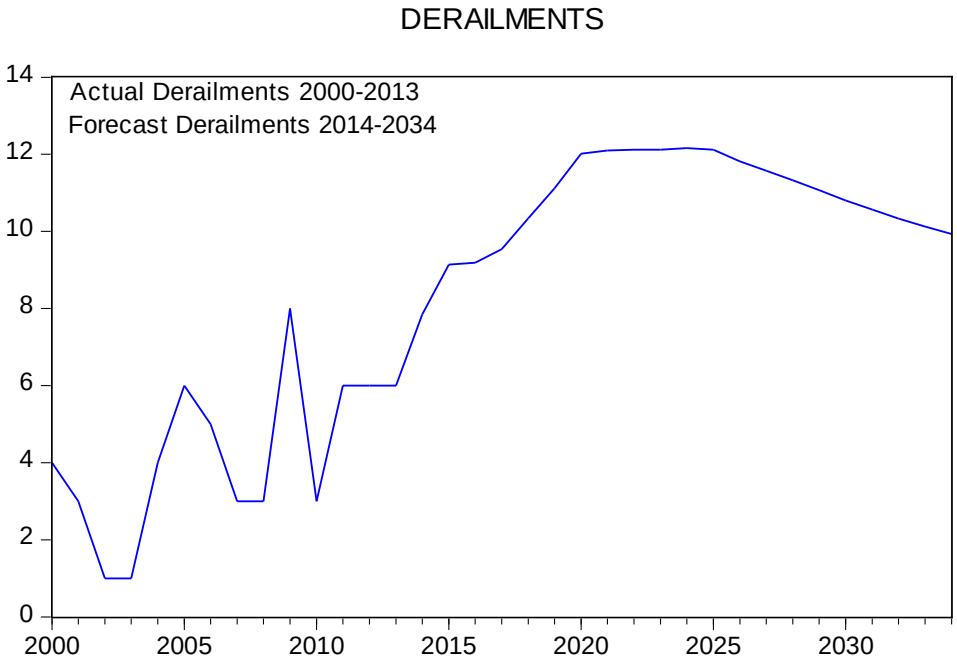
While there are strong reasons for using the Poisson framework (see Model), the results for carloads are robust to other methods. For example, the results for carloads are still positive and significant when running an ordinary least squares model or as a Negative Binomial model.

ACTUAL & FORECAST NUMBER OF DERAILMENTS

obs	Actual	Fitted	Residual
2000	4.00000	3.34235	0.65765
2001	3.00000	3.33821	-0.33821
2002	1.00000	3.35401	-2.35401
2003	1.00000	3.38114	-2.38114
2004	4.00000	3.41878	0.58122
2005	6.00000	3.44825	2.55175
2006	5.00000	3.65176	1.34824

2007	3.00000	3.87245	-0.87245
2008	3.00000	4.23517	-1.23517
2009	8.00000	4.51326	3.48674
2010	3.00000	4.85479	-1.85479
2011	6.00000	4.98631	1.01369
2012	6.00000	5.64621	0.35379
2013	6.00000	6.95731	-0.95731

We next forecast the number of derailments using the aforementioned Count Model and the forecast number of crude and ethanol carloads. The annual number of derailments range from between about 8 and 12 derailments. The graph below shows actual number of derailments (2000-2013) and the forecasted number using the Count Model (2014-2034).



The forecast number using the count model is less than using the forecast from the Simple Average forecast that we use in the main body of the analysis. As such, the Count Model forecast would produce a more conservative estimate of benefits. The table below shows forecast carloads, and forecast derailments using both methods. The final column shows the difference between the two methods.

		DERAILMENTS		
	Carloads Crude/Ethanol	Simple Average Forecast	Count Model Forecast	Δ
2014	957,052	10.18	7.85	2.33
2015	1,118,676	11.90	9.14	2.76
2016	1,123,624	11.95	9.18	2.77
2017	1,163,764	12.38	9.54	2.84
2018	1,249,753	13.29	10.34	2.95
2019	1,326,657	14.11	11.12	2.99
2020	1,409,245	14.99	12.02	2.97
2021	1,416,427	15.06	12.10	2.97
2022	1,418,355	15.09	12.12	2.96
2023	1,418,283	15.08	12.12	2.96
2024	1,422,075	15.13	12.16	2.96
2025	1,418,321	15.09	12.12	2.96
2026	1,391,469	14.80	11.82	2.98
2027	1,369,250	14.56	11.57	2.99
2028	1,346,322	14.32	11.33	2.99
2029	1,321,993	14.06	11.07	2.99
2030	1,295,989	13.78	10.80	2.98
2031	1,272,716	13.54	10.57	2.97
2032	1,248,469	13.28	10.33	2.95
2033	1,227,050	13.05	10.12	2.93
2034	1,206,705	12.83	9.93	2.90

Appendix G: Illustrative Approach to Higher-Consequence Event Damages

This information is included for illustrative purposes only to show higher-consequence damages using different assumptions. This appendix contains the same basic method for estimating higher-consequence event damages as used in the main analysis, employing a Monte Carlo simulation to run a large number of scenarios where the inputs are allowed to vary. See section VII.B.2 for a fuller discussion of the methods employed—this appendix focuses on the differences between the estimation here and the estimation in the main text. Where methodology is not fully described, it is the same as in the main analysis.

PHMSA used the estimated damages of the accident at Lac-Mégantic, Quebec, to illustrate the potential damages of a higher-consequence event, but because this accident was unique in many ways, PHMSA adjusted the damages downward to reflect the lower speeds and force that are more typical of derailments. For the main analysis, PHMSA adjusted the severity of Lac-Mégantic using the amount of energy dissipation that resulted from slowing the accident speed to a more typical derailment, but here uses another method. For this analysis, PHMSA looked at the FRA accident database which contains approximately 65,000 records for all types of accidents (e.g., derailments, grade crossings, collisions) on mainline and sidings from 1995 to 2013 and examined them to get a factor that includes severity as a function of train speed. Extracting only those accidents where the speed was greater than zero (0) and the number of cars derailed were greater the zero (0), the impact was binned by speed groups:

Table AG1: Average Number of Tank Car Derailments by MPH

Speed (mph)		Number of accidents	Number of tank cars derailed	Average number of Derailed Tank Cars	Ratio of the average number of derailed tank cars
Min	Max				
25	<40	2,083	18,957	9.1	N/A
40	<65	1,598	19,047	11.9	1.31

Here, PHMSA assumes the reduction in severity of an accident is given by the ratio of the average number of derailed cars in the speed bin from 40 to 64 mph to the average number of tank cars derailed at 25 to 39 mph. A slower speed, below 40 mph,[257] results in a 31 percent[258]

[257] In addition to applying a 50-mph speed limit to HHFTs, which is already in effect due to universal compliance with AAR's Circular OT-55-N, railroad subscribers agreed to adhere to a speed restriction of 40 mph for any HHFTs carrying crude oil in HTUAs, unless the tank cars all meet the CPC-1232 standard. This rulemaking will extend that speed restriction for HHFTs carrying ethanol, and will change the threshold tank car standard to the DOT-117 or DOT-117p.

reduction in severity, as measured by the average number of cars derailed. PHMSA considered whether derailment severity is an increasing function of speed, but the data support the 31 percent reduction. Thus PHMSA applies this factor to scale down the damages from Lac Mégantic from $1.1 billion to approximately $765 million[259] to account for a smaller expected number of cars derailed and lower speeds.

In the main analysis, PHMSA used two higher-consequence events as the central input for the Monte Carlo simulation, and allowed the number to vary between one and five. Here, PHMSA projects the number of higher consequence events over the next 20 years in the absence of this rule based on carloads shipped and an estimate of expected carloads over the next 20 years. There were approximately 5 million carloads of crude oil and ethanol shipped in Canada and the United States from 1995 – 2013, and over that time there was one higher-consequence event, the accident at Lac-Mégantic. PHMSA divides the total number of carloads shipped in US and Canada into the carloads we forecast to be shipped from 2015-2034 in the U.S. only: 26.2/5.3 = 4.94. Thus for this analysis, PHMSA estimates the number of higher consequence events that are likely to occur over the next 20 years in the absence of this rule at five events.

The table below presents the other input values that are used here:

Table AG2. Assumed Distribution of Input Values for Appendix XX Monte Carlo Analysis

Risk Variables	Probability Distribution	Point Estimate	Low	Mode	High
Number of events	Triangular*	5	50%	100%	150%
Percent of Population Fatalities	Triangular*	24%	75%	100%	110%
Baseline Non-Fatality Damage Value ($)	Triangular*	454,412,030	75%	100%	125%
Random Selection of Population Density	Custom**				
Wetlands ($)	Triangular*	14,654,932	75%	100%	125%
Wetlands Probability	Uniform	6%	2%		10%
*****We chose a triangular distribution for most elements because of its ease of use, only 3 parameters (lower limit, an upper limit and a mode) and allows for skewed distributions, like					

[259] $1,108,022,645 x (1- 0.3097) = $764,875,920.

Table AG2. Assumed Distribution of Input Values for Appendix XX Monte Carlo Analysis

the percent fatalities above. Additionally, with definite lower and upper limits we can avoid extreme values.

**The random selection of a population density is based on custom distributions with points given by the population densities in HTUAs and the rest of the HHFT rail network as illustrated in the table above titled "Population Densities along Crude Oil and Ethanol Rail Routes." The fuel network rail link lengths are used within HTUA/HHFT as a scaling factor to develop the population density custom distributions for HTUAs and HHFT networks, assuming the probability of having an accident is proportional to the link length. PHMSA uses the average annual tons transported on the fuel network to select in which area the accident occurs and is a proxy for the usage of the rail track in the HTUAs versus the rest of the HHFT network. Thus the probability of an accident occurring in the HTUA portion of the network is given by the ratio between the average annual tons transported in the HTUA network to the total tons transported in the entire HHFT network: 8,009,851,408 / 49,800,510,555.7 = 16.08%.

HTUAs account for 16.08% of the HHFT network. In each run of the simulation, a new, random number between 0 and 1 is generated. If this number is less than 0.1608, the incident is modeled as if taking place in a HTUA; otherwise, it is modeled as if taking place outside of a HTUA.

Below is the table showing a sampling of 30 possible sets of alternative outcomes (and the damages resulting from those outcomes) that might occur over the 20-year analysis period.

Table AG3. Sample Outputs of the Risk Model Showing 20-Year Values for Fatality and Non-Fatality Damages

Trial values	No. of Events	Percent Fatalities	Population Density per half-square km	Scaling Factor	Non-Fatality Damages* (million)	Damages Non-Fatality (million)	Damages Fatality (million)	Wetlands (million)	Total Damages (million)
1	6.1	23.1%	306.20	224.7%	$468.8	$6,457.6	$4,648.0	$0.0	$11,105.7
2	3.5	22.2%	55.06	40.4%	$387.7	$541.1	$451.8	$0.0	$992.9
3	3.4	24.2%	33.66	24.7%	$472.8	$397.8	$297.0	$0.0	$694.8
4	4.3	25.7%	1.46	1.1%	$425.5	$19.8	$17.4	$0.0	$37.2
5	7.0	23.0%	132.90	97.5%	$466.7	$3,176.9	$2,282.1	$0.0	$5,459.0
6	6.4	11.4%	0.05	0.0%	$245.6	$0.6	$0.4	$0.0	$1.0
7	4.1	24.9%	22.85	16.8%	$487.7	$336.4	$250.9	$0.0	$587.4
8	5.1	20.2%	36.84	27.0%	$378.7	$526.3	$410.5	$0.0	$936.8
9	4.1	22.2%	395.68	290.4%	$494.2	$5,943.8	$3,896.6	$0.0	$9,840.4
10	5.1	11.2%	0.00	0.0%	$199.2	$0.0	$0.0	$0.0	$0.0
11	5.9	20.7%	39.05	28.7%	$445.1	$756.2	$512.8	$0.0	$1,268.9
12	3.4	10.5%	2,741.63	2012.3%	$250.4	$17,208.4	$10,535.5	$0.0	$27,743.8
13	4.5	20.9%	273.15	200.5%	$523.4	$4,743.0	$2,761.2	$12.5	$7,516.6
14	4.3	22.5%	1.01	0.7%	$449.2	$14.4	$10.5	$0.0	$24.9

Table AG3. Sample Outputs of the Risk Model Showing 20-Year Values for Fatality and Non-Fatality Damages									
Trial values	No. of Events	Percent Fatalities	Population Density per half-square km	Scaling Factor	Non-Fatality Damages* (million)	Damages Non-Fatality (million)	Damages Fatality (million)	Wetlands (million)	Total Damages (million)
15	4.2	9.3%	0.13	0.1%	$212.3	$0.8	$0.5	$0.0	$1.4
16	4.7	23.7%	173.61	127.4%	$378.7	$2,243.9	$2,048.7	$0.0	$4,292.7
17	5.5	20.1%	182.03	133.6%	$404.9	$2,987.1	$2,169.5	$0.0	$5,156.6
18	5.3	24.1%	7.57	5.6%	$543.9	$158.8	$103.0	$0.0	$261.7
19	4.7	19.3%	332.90	244.3%	$396.4	$4,510.2	$3,205.9	$0.0	$7,716.1
20	4.5	24.2%	179.23	131.6%	$472.0	$2,789.2	$2,086.3	$0.0	$4,875.5
21	6.0	23.2%	77.92	57.2%	$364.3	$1,247.8	$1,160.4	$0.0	$2,408.2
22	6.5	10.2%	0.07	0.1%	$232.2	$0.8	$0.5	$0.0	$1.2
23	4.6	24.2%	298.66	219.2%	$426.9	$4,344.1	$3,601.3	$12.9	$7,958.2
24	5.1	23.5%	260.01	190.8%	$390.9	$3,836.1	$3,368.7	$0.0	$7,204.8
25	5.2	22.7%	198.82	145.9%	$475.0	$3,578.0	$2,498.5	$0.0	$6,076.5
26	4.6	24.0%	2.41	1.8%	$432.7	$35.3	$28.6	$0.0	$63.9
27	3.0	11.1%	1,391.93	1021.7 %	$219.4	$6,659.9	$4,915.4	$0.0	$11,575.3
28	3.3	23.4%	519.31	381.2%	$556.3	$6,904.6	$4,250.5	$0.0	$11,155.0
29	5.4	18.9%	666.92	489.5%	$484.8	$12,768.7	$7,266.8	$0.0	$20,035.5
30	5.3	22.2%	122.89	90.2%	$549.1	$2,621.6	$1,547.1	$0.0	$4,168.7
Note: *The values represent the Lac-Mégantic baseline non-fatality damages and vary randomly according to the triangular distribution of non-fatality damages set forth in table titled *Assumed Distribution of Input Values for Monte Carlo Analysis*.									

The distribution of total estimated damages from higher-consequence events over 20 years is shown as a percentile distribution from 0 percent to 100 percent in 5-percentile increments as follows:

Table AG4. Distribution of Total Estimated Damages From High-Consequence Events Over 20 Years								
Percentiles	No. of Events	Percent Fatalities	Population Density per half-square km	Scaling Factor relative to Lac-Mégantic	Damages Non-Fatality (million)	Damages Fatality (million)	Wetlands (million)	Total Damages (million)
0%	2.4	8.5%	0.0	0.0%	$0.0	$0.0	$0.0	$0.0
5%	3.2	10.4%	0.0	0.0%	$0.1	$0.0	$0.0	$0.1
10%	3.5	11.1%	0.1	0.1%	$1.0	$0.7	$0.0	$2.2
15%	3.7	11.8%	0.7	0.5%	$9.3	$6.5	$0.0	$18.1
20%	3.9	19.2%	2.7	2.0%	$42.5	$30.8	$0.0	$75.4
25%	4.1	20.0%	6.5	4.8%	$103.0	$73.2	$0.0	$177.9
30%	4.3	20.6%	13.1	9.6%	$201.6	$146.6	$0.0	$346.6
35%	4.4	21.1%	22.5	16.5%	$357.9	$259.6	$0.0	$618.5
40%	4.6	21.5%	35.8	26.3%	$551.4	$406.9	$0.0	$963.5
45%	4.7	21.9%	51.0	37.4%	$793.3	$576.9	$0.0	$1,369.2
50%	4.8	22.3%	72.3	53.1%	$1,121.1	$810.1	$0.0	$1,930.1
55%	4.9	22.6%	97.5	71.5%	$1,515.5	$1,110.1	$0.0	$2,630.2
60%	5.1	22.9%	127.0	93.2%	$2,036.7	$1,467.8	$0.0	$3,520.0
65%	5.2	23.2%	174.2	127.9%	$2,699.9	$1,962.2	$0.0	$4,668.6
70%	5.4	23.4%	231.6	170.0%	$3,588.0	$2,651.5	$0.0	$6,263.9
75%	5.5	23.7%	305.4	224.2%	$4,817.5	$3,488.7	$0.0	$8,290.7
80%	5.7	24.0%	412.7	302.9%	$6,457.6	$4,686.5	$0.0	$11,133.3
85%	5.9	24.3%	547.7	402.0%	$8,666.3	$6,308.5	$0.0	$14,945.3
90%	6.2	24.7%	845.9	620.8%	$12,779.3	$9,210.3	$0.0	$21,944.4
95%	6.5	25.1%	1,512.4	1110.1%	$20,572.6	$14,870.9	$13.0	$35,601.9
100%	7.2	26.2%	21,526.0	15799.7%	$224,785.5	$144,504.1	$18.2	$369,289.6

The median of the distribution (i.e., the 50th percentile) is approximately $1.9 billion. The mean, $7.8 billion, represents the average of all possible future outcomes (including some with extremely high damages); the median represents the outcome that has an equal probability that the actual outcome will be higher or lower than the median. The 80th percentile value ($11.1 billion) indicates that there is a 20-percent chance that the damages could be higher than $11.1 billion.

EXHIBIT 3

Ovintiv Safety Data Sheet (U.S.)

Black Wax Crude Oil

1.0 Identification

GHS product identifier: crude oil (black wax crude oil)	**Version #:** 01
Synonyms: black wax oil, Utah crude, crude petroleum, Utah black crude, black crude	**Issue date:** 09/09/2019
CAS #: 8002-05-9 (crude oil)	
Recommended use: process stream, fuels, and lubricants production	
Recommended restrictions: Use in accordance with this SDS.	
Manufacturer: Ovintiv USA Inc., 370 17th Street, Suite 1700, Denver, CO 80202	
Emergency phone #: 800-262-8200 or 911	**Email:** myEHS@ovintiv.com

2.0 Hazard Identification

2.1 GHS Classification and Label Elements

Signal Word: Danger			
Type of Hazard		**Category**	**Hazard Symbol**
Physical hazards	Flammable liquids	3	
Health hazards	Germ cell mutagenicity Carcinogenicity Specific target organ toxicity, single exposure Specific target organ toxicity, repeat exposure Aspiration hazard	2 1A 3 2 1	
Environmental hazards	Chronic toxicity to the aquatic environment	2	

2.2 Hazard Statement

- Flammable liquid and vapor.
- May be fatal if swallowed and enters airways.
- Causes mild skin irritation.
- Causes serious eye irritation.
- May cause respiratory irritation (respiratory tract).
- May cause drowsiness or dizziness.

- Suspected of causing genetic defects.
- May cause cancer.
- May cause damage to organs (liver, kidneys, blood, nervous system, and skin) through prolonged or repeated exposure.
- Harmful to aquatic life.
- Very toxic to aquatic life with long lasting effects (long-term, chronic).

2.3 Precautionary Statement

- Prevention
  - Obtain special instructions before use.
  - Do not handle until all safety precautions have been read and understood.
  - Keep away from heat/sparks/open flames/hot surfaces. No smoking.
  - Keep container tightly closed.
  - Keep cool.
  - Ground/bond container and receiving equipment.
  - Use explosion-proof electrical/ventilating/lighting equipment.
  - Use only non-sparking tools.
  - Take precautionary measures against static discharge.
  - Do not breathe gas/mist/vapors/spray.
  - Do not eat, drink, or smoke when using this product.
  - Avoid release to the environment.
  - Wear protective gloves/protective clothing/eye protection/face protection.
- Response
  - If swallowed, immediately call POISON CENTER or doctor/physician.
  - If on skin or hair, wash with plenty of soap and water. Remove/take off immediately all contaminated clothing. Rinse skin with water/shower.
  - If inhaled, remove victim to fresh air and keep at rest in a position comfortable for breathing.
  - If exposed or concerned, get medical advice/attention.
  - Call poison center/doctor if you feel unwell.

- Specific treatment (see first aid instructions on this SDS).
- Do NOT induce vomiting.
- If skin irritation occurs, get medical advice/attention.
- Take off contaminated clothing and wash before reuse.
- In case of fire, use water spray, fog, or firefighting foam.
- Collect spillage.

- Storage
  - Store in a well-ventilated place.
  - Keep container tightly closed.
  - Keep cool.
  - Store locked up.
- Disposal
  - Dispose of contents/container in accordance with local/regional/national/international regulations.
- Hazards not otherwise classified
  - Flammable gases can be entrained in storage vessels or tanks as the liquid fuel evaporates and emits vapors. These vapors can cause health effects and create physical hazards such as flash fires or even explosions.

3.0 Composition/Information on Ingredients

Components	CAS #	Percent (Weight)
Petroleum crude oil	8002-05-9	100%
Gasoline distillates	8006-61-9	<15-19%
Jet fuel distillates	8008-20-6	<7-11%
Diesel fuel distillates	68334-30-5	<5-9%
Benzene	71-43-2	Variable
Propane	74-98-6	Variable
Hydrogen sulfide	7783-06-4	Variable
Ethane	74-84-0	Variable
Methane	74-82-8	Variable
n-Hexane	110-54-3	Variable
Pentane	109-66-0	Variable
Butane	106-97-8	Variable
Xylenes	1330-20-7	Variable

Components	CAS #	Percent (Weight)
Toluene	108-88-3	Variable
Ethylbenzene	100-41-4	Variable
Polynuclear aromatic hydrocarbons	N/A	Variable

4.0 First Aid Measures

4.1 First Aid Procedures

- Inhalation: Inhalation of vapor may irritate the nose, throat, and respiratory tract. Coughing, sneezing, and shortness of breath may occur following exposure. Inhalation may cause rapid heart rate, headaches, confusion, anemia, dizziness, and drowsiness. Possible asphyxiation hazards could occur from hydrogen sulfide, methane, and other gases.
    - Remove person to fresh air. If person is not breathing, provide artificial respiration, CPR, or oxygen. If necessary, provide additional oxygen once breathing is restored, person applying oxygen should be trained to do so. Person should seek medical attention immediately from a physician should irritation persist or develop at a later time.
- Eye contact: Direct contact with liquid or vapor may cause irritation or burn the eyes.
    - Immediately flush eyes with clean water for 15 minutes while holding open the eyelids. Lift eyelids to ensure rinsing. Beyond flushing, seek medical attention from a physician.
- Ingestion: Ingestion is extremely irritating to mouth, throat, and gastrointestinal tract. May cause excitation, loss of consciousness, convulsion, cyanosis, congestion, and capillary hemorrhaging of the lungs and internal organs.
    - Seek emergency medical attention immediately. Never attempt to make an unconscious person, or person of limited awareness drink or vomit. DO NOT INDUCE VOMITING. If vomiting is occurring, lean victim forward, trying to keep them sitting at rest and comfortable. Monitor breathing, if person is conscious and fully aware, allow victim to rinse their mouth with water until taste and material has been removed.
- Dermal: Direct contact with skin may cause irritation.
    - Wash with soap and water. Remove contaminated clothing and decontaminate clothing before wearing again. Seek medical attention from a physician if irritation should persist or redness develops at a later time. Thermal burns require immediate medical attention depending on the area of the body burned and the severity.

5.0 Fire-Fighting Measures

5.1 Flammable Properties

- Vapors may be ignited quickly when exposed to sources of ignition (open flame, heat, spark, and others).
- Vapors can burn openly or explode in confined spaces when mixed with air and exposed to ignition source.

- Flash back may occur with vapors traveling an extended distance to an ignition source due to their density. Some vapors present may be lighter or heavier than air.
- See Sections 9.0 Physical and Chemical Properties and 10.0 Stability and Reactivity for physical/chemical and stability/reactive properties.
- NFPA: health 2, flammability 3, instability: 0.

Extinguishing Media

Suitable	Do Not Use
• For large fires: ○ Water spray. Water may be ineffective for fighting the fire but may be used to cool fire-exposed containers. ○ Fog. ○ Firefighting foam. • For small fires: ○ Any extinguisher suitable for Class B fires, dry chemical, CO_2, water spray, firefighting foam, or gaseous extinguishing agent may be used.	• Water jet, which will spread the fire.

Protection of Fire-Fighters

Specific Hazards Arising from Product	Protective Equipment and Precautions
• Small fires in the early stage may be able to be extinguished using a handheld fire extinguisher or other firefighting equipment. • For massive fires the sue of unmanned hose holders or monitor nozzle may be advantageous to further minimize personnel exposure. • Major fires may require withdrawal, allowing the tank to burn. • Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied firefighting foam.	• Fire-fighters should wear appropriate protective equipment and a self-contained breathing apparatus (SCBA) with full-face piece operated in positive pressure mode if fighting fire in poorly ventilated area.

5.2 Fire-Fighting Equipment/Instructions

- Evacuate area and fight fire from a safe distance.
- Evacuate area.
- Water spray should be used to cool containers.
- Containers can burst violently when heated, due to excess pressure build-up.

6.0 Accidental Release Measures

- Personal precautions:
  - Response and clean-up personnel must be properly trained in spill response and clean-up.
  - Avoid direct contact with material; use the personal protective equipment specified in Section 8.0 Exposure Controls/Personal Protection.
  - Personnel must utilize proper personal protective equipment (PPE) and engineering controls where applicable.
- Emergency procedures, if safe to do so:
  - Carefully contain and stop the source of spill.
  - Evacuate nonessential personnel and remove or secure all ignition sources.
  - Stay upwind if possible, to consider potential exposure to vapors as product may release a substantial amount of potentially toxic and flammable vapors.
  - If possible, remove heat and potential ignition sources to lessen the risk of fire.
  - Consider the direction the spilled product is moving/flowing; place damming or diking materials to prevent the product from entering sewers, waterways, drains, and confined areas.
  - Provide explosion-proof clearing ventilation, if possible. Use a LEL meter and H_2S (or 4-gas) meter to determine air quality in area.
  - Should a release of this product enter a US waterway and cause a film or sheen, the National Response Center must be notified within 24 hours at 800-424-8802.
- Methods for cleaning up, if safe to do so:
  - Carefully contain and stop the source of spill.
  - Pump or vacuum residual liquids into appropriate tanks or containers for recycle or disposal.
  - Collect oil and oil impacted soils, debris, and stage in approved DOT containers or on suitable liner material for staging and classification for recycle or disposal.
  - Use oil absorbing materials to soak up spill if small and contained.
  - Carefully shovel, scoop, or sweep up absorbed materials into a preferential waste container or approved DOT container for reclamation or disposal.
  - Oil and oil impacted materials recovered in cleanup operations should be disposed of in accordance with any applicable laws, regulation, or requirements.

7.0 Handling and Storage

7.1 Safe Handling Precautions

- Crude oil is a flammable liquid and should be handled as such.
- Liquid fuel can evaporate and emit gaseous vapors. These vapors can cause health effects and create physical hazards such as flash fires or even explosions.
- Avoid contact with product and avoid inhalation.
- Keep away from heat, sparks, and open flame.
- Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.
- Transfer equipment should be fixed wit self-closing valves, pressure vacuum bungs, and flame arrestors.
- Empty containers may contain residue of liquid or vapor and can be dangerous.
- Do not pressurize, cut, weld, drill or expose these containers to potential sources of ignition, as they may explode and case injury or death.
- Always wear appropriate personal protective equipment when handling product.
- Wash hands and face after handling and before eating, drinking, or smoking.
- HMIS: health: 2, flammability: 3, physical hazards: 0.

7.2 Conditions for Safe Storage Including Incompatibilities

- Store in a well-ventilated, cool, dry place away from heat, sunlight, hot surfaces, or other sources of ignition.
- Use only approved containers for storage and transport.
- Keep incompatible materials away.
- Crude oil is incompatible with strong oxidizers (Section 10.0 Stability and Reactivity).

8.0 Exposure Controls/Personal Protection

Occupational Exposure Limits

Component	Limit Type	OSHA PEL	ACGIH TLV	NIOSH REL
Benzene CAS # 71-43-2	STEL TWA	25 ppm 10 ppm[1]	2.5 ppm 0.5 ppm	1 ppm 0.1 ppm
Hydrogen sulfide CAS # 7783-06-4	STEL TWA	20 ppm[1] None	1 ppm 5 ppm	10 ppm None
Pentane CAS # 109-66-0	STEL TWA	None 1000 ppm	None 1000 ppm	610 ppm 120 ppm
n-Hexane CAS # 110-54-3	STEL TWA	None 500 ppm	None 50 ppm	None 50 ppm
Butane CAS # 106-97-8	STEL TWA	None None	1000 ppm None	None 800 ppm
Xylenes CAS# 95-47-6	STEL TWA	None 100 ppm	150 ppm 100 ppm	150 ppm 100 ppm
Ethylbenzene CAS# 100-41-4	STEL TWA	None 100 ppm	None 20 ppm	125 ppm 100 ppm
Toluene CAS# 108-88-3	STEL TWA	300 ppm (C) 200 ppm	None 20 ppm	150 ppm 100 ppm

TABLE NOTES:

(1) Value from OSHA Table Z-2.

STEL=short-term exposure limit, PEL=permissible exposure limit, REL=recommended exposure limit, TLV=threshold limit value, TWA=time-weighted average, C=ceiling, ppm=parts per million.

8.1 Engineering Controls

- Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.
- Provide explosion-proof clearing ventilation, if possible.
- Gas monitors should be used to assess exposure.
- Multi-gas meters should be properly maintained and properly calibrated before use.
- Personnel utilizing gas monitoring equipment should be trained prior to use.

8.2 Personal Protective Equipment

- Eye face protection: Safety glasses or goggles re recommended when splashing or spraying is a possibility.
- Skin protection: Wear gloves constructed of nitrile or neoprene are recommended at a minimum. Other job-specific gloves may be required.
- Respiratory protection:

- A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed recommended exposure limits.
- Only properly trained, fit-tested, personnel should be in areas that require the use of a respirator.
- Protection provided by air-purifying respirators is limited.
- The use of positive pressure, air-supplied respirators may be necessary if there is a potential for release or in oxygen-deficient atmospheres.
- Air-supplied respirators should especially be used if exposure levels are unknown or any other circumstance where an air-purifying respirator may not provide the adequate protection.
- Respirator should also comply with OSHA requirements of personnel working with hazardous materials.
- OSHA requires personnel to be respirator trained, this training includes fit testing, medical clearance, repair and cleaning, and other requirements.

9.0 Physical and Chemical Properties

Physical state	Liquid
Color	Varies from light brown to black
Odor	Characteristics of petroleum scent
pH	Not applicable
Melting point/freezing point	MP not determined. FP <-62.7°C(-81°F)
Initial boiling point	-58.8°C (138°F)
Flash point	<28.8-37.7°C (84-100°F)
Lower explosive limit (by volume)	Variable
Upper explosive limit (by volume)	Variable
Vapor pressure	Variable
Vapor density	1.5-3.0 (estimated)
Relative density	Variable
Solubility	Soluble in hydrocarbon solvents Insoluble in water
Partition coefficient (n-octanol/water)	<0.1 (estimated)
Auto-ignition temperature	Not determined
Decomposition temperature	Not available
Viscosity	Not available

10.0 Stability and Reactivity

- Chemical stability: Stable at normal anticipated storage and handling temperatures and pressures. Crude oil is an extremely flammable liquid and vapors from it can cause flash fire.

Store the product in a well-ventilated, cool, dry place away from heat, sunlight, hot surfaces, or other sources of ignition. Use only approved containers for storage and transport. Crude oil will react with strong oxidizers.

- Possibility of hazardous reactions: Volatility of vapors can flash fires. Buildup of vapors is known to contribute to fires and may potentially cause explosions.

- Conditions to avoid: Avoid high temperatures and all possible sources of ignition: open flames, sparks, welding, and smoking. Prevent vapor accumulation. Do not store in improper containers. Keep incompatible materials from crude oil, as it is incompatible with strong oxidizers.

- Incompatible materials: Keep away from strong oxidizers such as acids, alkalis, chlorine and halogens, dichromates, or permanganates, which may cause fire or explosion.

- Hazardous decomposition products: Hazardous decomposition products are not expected with normal storage. The use of hydrocarbon fuel in an area without adequate ventilation may result in hazardous levels of combustion products: carbon monoxide, carbon dioxide, sulfur and nitrogen, benzene, and other hydrocarbons. Combustion can yield low oxygen levels. Other potential decomposition products include sulfur oxides, nitrogen oxides, and airborne particulates.

11.0 Toxicological Information

11.1 Routes of Exposure

- Ingestion: Ingestion may cause irritation to mouth, throat, and gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system effects similar to that of alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur along with other long-term health effects.

- Inhalation: Inhalation of vapor may irritate the nose, throat, and respiratory tract. Coughing, sneezing, and shortness of breath may occur following exposure. Inhalation may cause rapid heart rate, headaches, confusion, anemia, dizziness, and drowsiness. Possible asphyxiation hazards could occur from hydrogen sulfide, methane, and other vapors.

- Skin contact: Direct contact with skin may cause irritation.

- Eye contact: Direct contact with liquid or vapor may cause irritation or burn the eyes.

11.2 Toxicological Effects

- Acute effects: Suffocation (asphyxiant) hazard – if allowed to accumulate to concentrations that reduce oxygen levels below safe breathing levels. Exposure to rapidly expanding gas or vaporizing liquid may cause frostbite.

- Chronic effects: Prolonged or repeated exposure to high concentrations may affect the central nervous system.

11.3 Chronic Effects:

- Due to the presence of benzene, long-term exposure may increase the risk of anemia and leukemia. Repeated skin contact may increase the risk of skin cancer. Benzene, a constituent present in petroleum crude, is listed with IARC as Group 1, known carcinogen to human. The

NTP lists benzene as a Select Carcinogen: Known Human Carcinogen. Similarly, OSHA and ACGIH also list benzene as a carcinogen to humans.

- The evaluation of Petroleum Crude Oil by IARC concluded there is "inadequate evidence for the carcinogenicity in humans of crude oil" and that there is "limited evidence for the carcinogenicity in experimental animals of crude oil" and because of this, crude oil is "not classifiable as to its carcinogenicity to humans", Group 3. Similar evaluations have also been conducted by ACGIH, OSHA, and NTP. Crude oil is not listed as a carcinogen with NTP, OSHA, or ACGIH.

Component Toxicity

Component	LD_{50} Oral	LD_{50} Dermal	LC_{50}
Petroleum distillates/naphtha (8002-05-9)	>4,300 mg/kg (rat)	>2,000 mg/kg (rabbit)	>4,300 ppm (rat)
Benzene (71-43-2)	930 mg/kg (rat)	>9,400 µL/kg (rabbit)	10,000 ppm (7-hour, inhalation, rat)
Toluene (108-88-3)	2,600 mg/kg (rat)	14.1 mL/kg (rabbit)	49,000 mg/m^3 (4-hour, inhalation, rat)
Xylenes (95-47-6)	4,300 mg/kg (rat)	>1,700 mg/kg (rabbit)	5,000 ppm (4-hour, inhalation, rat)
Ethylbenzene (100-41-4)	3,500 mg/kg (rat)	17,800 µL/kg (rabbit)	Not available
Methane (74-82-8)	Not available	Not available	326,000 mg/m^3 (2-hour, inhalation, mouse)
Hydrogen sulfide (7783-06-4)	Not available	Not available	444 ppm (4-hour, inhalation, rat)

12.0 Ecological Information

- Ecotoxicity: Keep product out of sewers, drainage areas, and waterways. All spills and releases should be reported where applicable under appropriate regulations. When any release to the environment occurs, components of the crude oil will divide or partition into various environmental compartments. Components with the lower molecular weights may dissolve in water or volatilize to the atmosphere. Components of intermediate fractions may float on or spread out in water, where the fractions may form emulsions, or adsorb into soil and other sediments. Viscous components or component with heavier or higher molecular weights may amass together and float or sink in water or stick to soil and sediment. The rate at which this occur is completely reliant on the make-up of the crude.

- Persistence and degradability: Crude oils are subject to biodegradation, but biodegradation rates vary considerably, and crude oils are not considered "readily biodegradable".

- Mobility in soil: Low molecular weight aliphatic and aromatic components of crude are generally expected to have a high rate of mobility in soil. Heavier molecular weighted components are expected to have a lesser rate of mobility in soil.

- Bioaccumulative potential:

- Polycyclic aromatic hydrocarbons (PAHs) found in crude oil can be highly toxic to zooplankton and can be accumulated and moved-up throughout the food webs. According to MARPOL 73/78 ANNEX I, crude oil is considered a marine pollutant and based on studies is considered toxic to marine life.
- Petroleum distillates/naptha (8002-05-9) (USEPA 2011):
  - LC_{50} for fish ranges 0.73-42 mg/L (96-hour)
  - EC_{50} aquatic invertebrates 0.61-28 mg/L (48-hour)
  - Chronic toxicity to aquatic invertebrates from 0.5-6 mg/L (21-day)

- Other adverse effects: Numerous studies have been conducted on various types of crude oil to determine its effects on the environment. Limited studies have been conducted on formation-specific yellow wax crude oil to determine its effects on the environment. In general, crude oil releases can have negative effects on marine ecological environments, as well as the terrestrial environment, to what degree is dependent on the makeup of the crude oil and the size of release.

13.0 Disposal Considerations

It is the responsibility of the user to determine if the material is considered hazardous for disposal under federal, state, and local regulations.

14.0 Transportation Information

US DOT

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class	3
Packing group	III
Environmental hazards: marine pollutant	Yes
Labels required	3
Packaging exceptions	150
Packaging non-bulk	202
Packaging bulk	242
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

IATA

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class(es)	3
Packing group	III

Environmental hazards	Yes
Label required	3
ERG code	3L
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

IMDG

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class(es)	3
Packing group	III
Environmental hazards: marine pollutant	Yes
Label required	3
EmS	F-E, S-E
Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not applicable. However, this product is a liquid and, if transported in bulk, is covered under MARPOL 73/78 Annex I.
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

15.0 Regulatory Information

U.S.

OSHA	This product is a hazardous chemical, as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
TSCA	This product is not listed in the TSCA chemical inventory.
SARA Section 302	This product contains hydrogen sulfide, which has been listed on the EPA's extremely hazardous substance list.
SARA Section 304	This product may contain the following component(s) that in the event of a spill may be subject to SARA reporting requirements: benzene, ethyl benzene toluene, xylene, n-hexane.
SARA Section 311/312	The following categories apply to this product: acute health hazard, chronic health hazard, fire hazard.
SARA Section 313	This product may contain the following component(s) that may be subject to reporting on a toxic release inventory: benzene, ethyl benzene, toluene, n-hexane, xylene.

EPA Clean Water Act	Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 800-424-8802.

International Inventories

Country or Region	Inventory Name	On Inventory (Yes/No)
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes

16.0 Other Information, Including Date of Preparation of Last Version

Issue date: 09/09/2019

Version #: 01

References: IARC Monographs. Overall Evaluation of Carcinogenicity (Volumes 1-102) IUCLID. Hazardous Substances Data Bank.

Disclaimer: This information is provided without warranty. The information is believed to be correct. This information should be used to make an independent determination of the methods to safeguard workers and the environment.

EXHIBIT 4

Ovintiv Safety Data Sheet (U.S.)

Yellow Wax Crude Oil

1.0 Identification

GHS product identifier: crude oil (yellow wax crude oil)	**Version #:** 01
Synonyms: yellow wax oil, Utah crude, crude petroleum, Utah yellow crude, and yellow crude	**Issue date:** 09/09/2019
CAS #: 8002-05-9 (crude oil)	
Recommended use: process stream, fuels, lubricants production	
Recommended restrictions: Use in accordance with this SDS.	
Manufacturer: Ovintiv USA Inc., 370 17th Street, Suite 1700, Denver, CO 80202	
Emergency phone #: 800-262-8200 or 911	**Email:** myEHS@ovintiv.com

2.0 Hazard Identification

2.1 GHS Classification and Label Elements

Signal Word: Danger			
Type of Hazard		**Category**	**Hazard Symbol**
Physical hazards	Flammable liquids	3	
Health hazards	Germ cell mutagenicity Carcinogenicity Specific target organ toxicity, single exposure Specific target organ toxicity, repeat exposure Aspiration hazard	2 1A 3 2 1	
Environmental hazards	Chronic toxicity to the aquatic environment	2	

2.2 Hazard Statement

- Flammable liquid and vapor.
- May be fatal if swallowed and enters airways.
- Causes mild skin irritation.
- Causes serious eye irritation.
- May cause respiratory irritation (respiratory tract).
- May cause drowsiness or dizziness.

- Suspected of causing genetic defects.
- May cause cancer.
- May cause damage to organs (liver, kidneys, blood, nervous system, and skin) through prolonged or repeated exposure.
- Harmful to aquatic life.
- Very toxic to aquatic life with long lasting effects (long-term, chronic).

2.3 Precautionary Statement

- Prevention
  - Obtain special instructions before use.
  - Do not handle until all safety precautions have been read and understood.
  - Keep away from heat/sparks/open flames/hot surfaces. No smoking.
  - Keep container tightly closed.
  - Keep cool.
  - Ground/bond container and receiving equipment.
  - Use explosion-proof electrical/ventilating/lighting equipment.
  - Use only non-sparking tools.
  - Take precautionary measures against static discharge.
  - Do not breathe gas/mist/vapors/spray.
  - Do not eat, drink, or smoke when using this product.
  - Avoid release to the environment.
  - Wear protective gloves/protective clothing/eye protection/face protection.
- Response
  - If swallowed, immediately call POISON CENTER or doctor/physician.
  - If on skin or hair, wash with plenty of soap and water. Remove/take off immediately all contaminated clothing. Rinse skin with water/shower.
  - If inhaled, remove victim to fresh air and keep at rest in a position comfortable for breathing.
  - If exposed or concerned, get medical advice/attention.
  - Call poison center/doctor if you feel unwell.

- Specific treatment (see first aid instructions on this SDS).
- Do NOT induce vomiting.
- If skin irritation occurs, get medical advice/attention.
- Take off contaminated clothing and wash before reuse.
- In case of fire, use water spray, fog, or firefighting foam.
- Collect spillage.

- Storage
  - Store in a well-ventilated place.
  - Keep container tightly closed.
  - Keep cool.
  - Store locked up.
- Disposal
  - Dispose of contents/container in accordance with local/regional/national/international regulations.
- Hazards not otherwise classified
  - Flammable gases can be entrained in storage vessels or tanks as the liquid fuel evaporates and emits vapors. These vapors can cause health effects and create physical hazards such as flash fires or even explosions.

3.0 Composition/Information on Ingredients

Components	CAS #	Percent (Weight)
Petroleum crude oil	8002-05-9	100%
Gasoline distillates	8006-61-9	<13-17%
Jet fuel distillates	8008-20-6	<8-12%
Diesel fuel distillates	68334-30-5	<8-12%
Benzene	71-43-2	Variable
Propane	74-98-6	Variable
Hydrogen sulfide	7783-06-4	Variable
Ethane	74-84-0	Variable
Methane	74-82-8	Variable
n-Hexane	110-54-3	Variable
Pentane	109-66-0	Variable
Butane	106-97-8	Variable
Xylenes	1330-20-7	Variable

Components	CAS #	Percent (Weight)
Toluene	108-88-3	Variable
Ethylbenzene	100-41-4	Variable
Polynuclear aromatic hydrocarbons	N/A	Variable

4.0 First Aid Measures

4.1 First Aid Procedures

- Inhalation: Inhalation of vapor may irritate the nose, throat, and respiratory tract. Coughing, sneezing, and shortness of breath may occur following exposure. Inhalation may cause rapid heart rate, headaches, confusion, anemia, dizziness, and drowsiness. Possible asphyxiation hazards could occur from hydrogen sulfide, methane, and other gases.
    - Remove person to fresh air. If person is not breathing, provide artificial respiration, CPR, or oxygen. If necessary, provide additional oxygen once breathing is restored, person applying oxygen should be trained to do so. Person should seek medical attention immediately from a physician should irritation persist or develop at a later time.
- Eye contact: Direct contact with liquid or vapor may cause irritation or burn the eyes.
    - Immediately flush eyes with clean water for 15 minutes while holding open the eyelids. Lift eyelids to ensure rinsing. Beyond flushing, seek medical attention from a physician.
- Ingestion: Ingestion is extremely irritating to mouth, throat, and gastrointestinal tract. May cause excitation, loss of consciousness, convulsion, cyanosis, congestion, and capillary hemorrhaging of the lungs and internal organs.
    - Seek emergency medical attention immediately. Never attempt to make an unconscious person, or person of limited awareness drink or vomit. DO NOT INDUCE VOMITING. If vomiting is occurring, lean victim forward, trying to keep them sitting at rest and comfortable. Monitor breathing, if person is conscious and fully aware, allow victim to rinse their mouth with water until taste and material has been removed.
- Dermal: Direct contact with skin may cause irritation.
    - Wash with soap and water. Remove contaminated clothing and decontaminate clothing before wearing again. Seek medical attention from a physician if irritation should persist or redness develops at a later time. Thermal burns require immediate medical attention depending on the area of the body burned and the severity.

5.0 Fire-Fighting Measures

5.1 Flammable Properties

- Vapors may be ignited quickly when exposed to sources of ignition (open flame, heat, spark, and others).
- Vapors can burn openly or explode in confined spaces when mixed with air and exposed to ignition source.

- Flash back may occur with vapors traveling an extended distance to an ignition source due to their density. Some vapors present may be lighter or heavier than air.
- See Sections 9.0 Physical and Chemical Properties and 10.0 Stability and Reactivity for physical/chemical and stability/reactive properties.
- NFPA: health 2, flammability 3, instability: 0.

Extinguishing Media

Suitable	Do not use
• For large fires: ○ Water spray. Water may be ineffective for fighting the fire but may be used to cool fire-exposed containers. ○ Fog. ○ Firefighting foam. • For small fires: ○ Any extinguisher suitable for Class B fires, dry chemical, CO_2, water spray, firefighting foam, or gaseous extinguishing agent may be used.	• Water jet, which will spread the fire.

Protection of Fire-Fighters

Specific hazards arising from product	Protective equipment and precautions
• Small fires in the early stage may be able to be extinguished using a handheld fire extinguisher or other firefighting equipment. • For massive fires the sue of unmanned hose holders or monitor nozzle may be advantageous to further minimize personnel exposure. • Major fires may require withdrawal, allowing the tank to burn. • Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied firefighting foam.	• Fire-fighters should wear appropriate protective equipment and a self-contained breathing apparatus (SCBA) with full-face piece operated in positive pressure mode if fighting fire in poorly ventilated area.

5.2 Fire-Fighting Equipment/Instructions

- Evacuate area and fight fire from a safe distance.
- Evacuate area.
- Water spray should be used to cool containers.
- Containers can burst violently when heated, due to excess pressure build-up.

6.0 Accidental Release Measures

- Personal precautions:
  - Response and clean-up personnel must be properly trained in spill response and clean-up.
  - Avoid direct contact with material; use the personal protective equipment specified in Section 8 Exposure Controls/Personal Protection.
  - Personnel must utilize proper personal protective equipment (PPE) and engineering controls where applicable.
- Emergency procedures, if safe to do so:
  - Carefully contain and stop the source of spill.
  - Evacuate nonessential personnel and remove or secure all ignition sources.
  - Stay upwind if possible, to consider potential exposure to vapors as product may release a substantial amount of potentially toxic and flammable vapors.
  - If possible, remove heat and potential ignition sources to lessen the risk of fire.
  - Consider the direction the spilled product is moving/flowing; place damming or diking materials to prevent the product from entering sewers, waterways, drains, and confined areas.
  - Provide explosion-proof clearing ventilation, if possible. Use a LEL meter and H_2S (or 4-gas) meter to determine air quality in area.
  - Should a release of this product enter a US waterway and cause a film or sheen, the National Response Center must be notified within 24 hours at 800-424-8802.
- Methods for cleaning up, if safe to do so:
  - Carefully contain and stop the source of spill.
  - Pump or vacuum residual liquids into appropriate tanks or containers for recycle or disposal.
  - Collect oil and oil impacted soils, debris, and stage in approved DOT containers or on suitable liner material for staging and classification for recycle or disposal.
  - Use oil absorbing materials to soak up spill if small and contained.
  - Carefully shovel, scoop, or sweep up absorbed materials into a preferential waste container or approved DOT container for reclamation or disposal.
  - Oil and oil impacted materials recovered in cleanup operations should be disposed of in accordance with any applicable laws, regulation, or requirements.

7.0 Handling and Storage

7.1 Safe Handling Precautions

- Crude oil is a flammable liquid and should be handled as such.
- Liquid fuel can evaporate and emit gaseous vapors. These vapors can cause health effects and create physical hazards such as flash fires or even explosions.
- Avoid contact with product and avoid inhalation.
- Keep away from heat, sparks, and open flame.
- Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.
- Transfer equipment should be fixed wit self-closing valves, pressure vacuum bungs, and flame arrestors.
- Empty containers may contain residue of liquid or vapor and can be dangerous.
- Do not pressurize, cut, weld, drill, or expose these containers to potential sources of ignition, as they may explode and cause injury or death.
- Always wear appropriate personal protective equipment (PPE) when handling product.
- Wash hands and face after handling and before eating, drinking, or smoking.
- HMIS: health: 2, flammability: 3, physical hazards: 0.

7.2 Conditions for Safe Storage Including Incompatibilities

- Store in a well-ventilated, cool, dry place away from heat, sunlight, hot surfaces, or other sources of ignition.
- Use only approved containers for storage and transport.
- Keep incompatible materials away.
- Crude oil is incompatible with strong oxidizers (Section 10.0 Stability and Reactivity).

8.0 Exposure Controls/Personal Protection

Occupational Exposure Limits

Component	Limit Type	OSHA PEL	ACGIH TLV	NIOSH REL
Benzene CAS # 71-43-2	STEL TWA	25 ppm 10 ppm[1]	2.5 ppm 0.5 ppm	1 ppm 0.1 ppm
Hydrogen sulfide CAS # 7783-06-4	STEL TWA	20 ppm[1] None	1 ppm 5 ppm	10 ppm None
Pentane CAS # 109-66-0	STEL TWA	None 1000 ppm	None 1000 ppm	610 ppm 120 ppm
n-Hexane CAS # 110-54-3	STEL TWA	None 500 ppm	None 50 ppm	None 50 ppm
Butane CAS # 106-97-8	STEL TWA	None None	1000 ppm None	None 800 ppm
Xylenes CAS# 95-47-6	STEL TWA	None 100 ppm	150 ppm 100 ppm	150 ppm 100 ppm
Ethylbenzene CAS# 100-41-4	STEL TWA	None 100 ppm	None 20 ppm	125 ppm 100 ppm
Toluene CAS# 108-88-3	STEL TWA	300 ppm (C) 200 ppm	None 20 ppm	150 ppm 100 ppm

TABLE NOTES:

(1) Value from OSHA Table Z-2.

STEL=short-term exposure limit, PEL=permissible exposure limit, REL=recommended exposure limit, TLV=threshold limit value, TWA=time-weighted average, C=ceiling, ppm=parts per million.

8.1 Engineering Controls

- Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.
- Provide explosion-proof clearing ventilation, if possible.
- Gas monitors should be used to assess exposure.
- Multi-gas meters should be properly maintained and properly calibrated before use.
- Personnel utilizing gas monitoring equipment should be trained prior to use.

8.2 Personal Protective Equipment

- Eye face protection: Safety glasses or goggles re recommended when splashing or spraying is a possibility.
- Skin protection: Wear gloves constructed of nitrile or neoprene are recommended at a minimum. Other job-specific gloves may be required.

- Respiratory protection:
    - A NIOSH/MSHA-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed recommended exposure limits.
    - Only properly trained, fit-tested personnel should be in areas that require the use of a respirator.
    - Protection provided by air-purifying respirators is limited.
    - The use of positive pressure, air-supplied respirators may be necessary if there is a potential for release or in oxygen-deficient atmospheres.
    - Air-supplied respirators should especially be used if exposure levels are unknown or any other circumstance where an air-purifying respirator may not provide the adequate protection.
    - Respirator should also comply with OSHA requirements of personnel working with hazardous materials.
    - OSHA requires personnel to be respirator trained, this training includes fit testing, medical clearance, repair and cleaning, and other requirements.

9.0 Physical and Chemical Properties

Physical state	Liquid
Color	Varies from light color to dark brown or greenish black liquid
Odor	Characteristics of petroleum scent
pH	Not applicable
Melting point/freezing point	MP not determined. FP <-60°C(-76°F)
Initial boiling point	-78.8°C (174°F)
Flash point	<28.8-37.7°C (84-100°F)
Lower explosive limit (by volume)	1% (estimated)
Upper explosive limit (by volume)	15% (estimated)
Vapor pressure	Variable
Vapor density	1.5-3.0 (estimated)
Relative density	Variable
Solubility	Insoluble to slight solubility
Partition coefficient (n-octanol/water)	<0.1 (estimated)
Auto-ignition temperature	Not determined
Decomposition temperature	Not available
Viscosity	Variable

10.0 Stability and Reactivity

- Chemical stability: Stable at normal anticipated storage and handling temperatures and pressures. Crude oil is an extremely flammable liquid and vapors from it can cause flash fire. Store the product in a well-ventilated, cool, dry place away from heat, sunlight, hot surfaces, or other sources of ignition. Use only approved containers for storage and transport. Crude oil will react with strong oxidizers.

- Possibility of hazardous reactions: Volatility of vapors can flash fires. Buildup of vapors is known to contribute to fires and may potentially cause explosions.

- Conditions to avoid: Avoid high temperatures and all possible sources of ignition: open flames, sparks, welding, and smoking. Prevent vapor accumulation. Do not store in improper containers. Keep incompatible materials from crude oil, as it is incompatible with strong oxidizers.

- Incompatible materials: Keep away from strong oxidizers such as acids, alkalis, chlorine and halogens, dichromates, or permanganates, which may cause fire or explosion.

- Hazardous decomposition products: Hazardous decomposition products are not expected with normal storage. The use of hydrocarbon fuel in an area without adequate ventilation may result in hazardous levels of combustion products: carbon monoxide, carbon dioxide, sulfur and nitrogen, benzene, and other hydrocarbons. Combustion can yield low oxygen levels. Other potential decomposition products include sulfur oxides, nitrogen oxides, and airborne particulates.

11.0 Toxicological Information

11.1 Routes of Exposure

- Ingestion: Ingestion may cause irritation to mouth, throat, and gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system effects similar to that of alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur along with other long-term health effects.

- Inhalation: Inhalation of vapor may irritate the nose, throat, and respiratory tract. Coughing, sneezing, and shortness of breath may occur following exposure. Inhalation may cause rapid heart rate, headaches, confusion, anemia, dizziness, and drowsiness. Possible asphyxiation hazards could occur from hydrogen sulfide, methane, and other vapors.

- Skin contact: Direct contact with skin may cause irritation.

- Eye contact: Direct contact with liquid or vapor may cause irritation or burn the eyes.

11.2 Toxicological Effects

- Acute effects: Suffocation (asphyxiant) hazard – if allowed to accumulate to concentrations that reduce oxygen levels below safe breathing levels. Exposure to rapidly expanding gas or vaporizing liquid may cause frostbite.

- Chronic effects: Prolonged or repeated exposure to high concentrations may affect the central nervous system.

11.3 Chronic Effects:

- Due to the presence of benzene, long-term exposure may increase the risk of anemia and leukemia. Repeated skin contact may increase the risk of skin cancer. Benzene, a constituent present in petroleum crude, is listed with IARC as Group 1, known carcinogen to human. The NTP lists benzene as a Select Carcinogen: Known Human Carcinogen. Similarly, OSHA and ACGIH also list benzene as a carcinogen to humans.

- The evaluation of Petroleum Crude Oil by IARC concluded there is "inadequate evidence for the carcinogenicity in humans of crude oil" and that there is "limited evidence for the carcinogenicity in experimental animals of crude oil" and because of this, crude oil is "not classifiable as to its carcinogenicity to humans", Group 3. Similar evaluations have also been conducted by ACGIH, OSHA, and NTP. Crude oil is not listed as a carcinogen with NTP, OSHA, or ACGIH.

Component Toxicity

Component	LD_{50} Oral	LD_{50} Dermal	LC_{50}
Petroleum distillates/naphtha (8002-05-9)	>4,300 mg/kg (rat)	>2,000 mg/kg (rabbit)	>4,300 ppm (rat)
Benzene (71-43-2)	930 mg/kg (rat)	>9,400 µL/kg (rabbit)	10,000 ppm (7-hour, inhalation, rat)
Toluene (108-88-3)	2,600 mg/kg (rat)	14.1 mL/kg (rabbit)	49,000 mg/m^3 (4-hour, inhalation, rat)
Xylenes (95-47-6)	4,300 mg/kg (rat)	>1,700 mg/kg (rabbit)	5,000 ppm (4-hour, inhalation, rat)
Ethylbenzene (100-41-4)	3,500 mg/kg (rat)	17,800 µL/kg (rabbit)	Not available
Methane (74-82-8)	Not available	Not available	326,000 mg/m^3 (2-hour, inhalation, mouse)
Hydrogen sulfide (7783-06-4)	Not available	Not available	444 ppm (4-hour, inhalation, rat)

12.0 Ecological Information

- Ecotoxicity: Keep product out of sewers, drainage areas, and waterways. All spills and releases should be reported where applicable under appropriate regulations. When any release to the environment occurs, components of the crude oil will divide or partition into various environmental compartments. Components with the lower molecular weights may dissolve in water or volatilize to the atmosphere. Components of intermediate fractions may float on or spread out in water, where the fractions may form emulsions, or adsorb into soil and other sediments. Viscous components or component with heavier or higher molecular weights may amass together and float or sink in water or stick to soil and sediment. The rate at which this occur is completely reliant on the make-up of the crude.

- Persistence and degradability: Crude oils are subject to biodegradation, but biodegradation rates vary considerably, and crude oils are not considered "readily biodegradable".

- Mobility in soil: Low molecular weight aliphatic and aromatic components of crude are generally expected to have a high rate of mobility in soil. Heavier molecular weighted components are expected to have a lesser rate of mobility in soil.

- Bioaccumulative potential:

    - Polycyclic aromatic hydrocarbons (PAHs) found in crude oil can be highly toxic to zooplankton and can be accumulated and moved-up throughout the food webs. According to MARPOL 73/78 ANNEX I, crude oil is considered a marine pollutant and based on studies is considered toxic to marine life.

    - Petroleum distillates/naptha (8002-05-9) (USEPA 2011):

        - LC_{50} for fish ranges 0.73-42 mg/L (96-hour)

        - EC_{50} aquatic invertebrates 0.61-28 mg/L (48-hour)

        - Chronic toxicity to aquatic invertebrates from 0.5-6 mg/L (21-day)

- Other adverse effects: Numerous studies have been conducted on various types of crude oil to determine its effects on the environment. Limited studies have been conducted on formation-specific yellow wax crude oil to determine its effects on the environment. In general, crude oil releases can have negative effects on marine ecological environments, as well as the terrestrial environment, to what degree is dependent on the makeup of the crude oil and the size of release.

13.0 Disposal Considerations

It is the responsibility of the user to determine if the material is considered hazardous for disposal under federal, state, and local regulations.

14.0 Transportation Information

US DOT

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class	3
Packing group	III
Environmental hazards: marine pollutant	Yes
Labels required	3
Packaging exceptions	150
Packaging non-bulk	202
Packaging bulk	242
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

IATA

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class(es)	3
Packing group	III
Environmental hazards	Yes
Label required	3
ERG code	3L
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

IMDG

UN number	1267
UN proper shipping name	Petroleum Crude Oil
Transport hazardous class(es)	3
Packing group	III
Environmental hazards: marine pollutant	Yes
Label required	3
EmS	F-E, S-E
Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not applicable. However, this product is a liquid and, if transported in bulk, is covered under MARPOL 73/78 Annex I.
Special precautions for the user	Read safety instructions, SDS, and emergency procedures before handling.

15.0 Regulatory Information

U.S.

OSHA	This product is a hazardous chemical, as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
TSCA	This product is not listed in the TSCA chemical inventory.
SARA Section 302	This product contains hydrogen sulfide, which has been listed on the EPA's extremely hazardous substance list.
SARA Section 304	This product may contain the following component(s) that in the event of a spill may be subject to SARA reporting requirements: benzene, ethyl benzene toluene, xylene, n-hexane.
SARA Section 311/312	The following categories apply to this product: acute health hazard, chronic health hazard, fire hazard.

SARA Section 313	This product may contain the following component(s) that may be subject to reporting on a toxic release inventory: benzene, ethyl benzene, toluene, n-hexane, xylene.
EPA Clean Water Act	Spills into or leading to surface waters that cause a sheen must be reported to the National Response Center, 800-424-8802.

International Inventories

Country or Region	Inventory Name	On Inventory (Yes/No)
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes

16.0 Other Information, Including Date of Preparation of Last Version

Issue date: 09/09/2019

Version #: 01

References: IARC Monographs. Overall Evaluation of Carcinogenicity (Volumes 1-102) IUCLID. Hazardous Substances Data Bank.

Disclaimer: This information is provided without warranty. The information is believed to be correct. This information should be used to make an independent determination of the methods to safeguard workers and the environment.

EXHIBIT 5

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The Royal Society of Canada
The Academies of Arts, Humanities and Sciences of Canada

SRC
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Les Académies des arts, des lettres et des sciences du Canada

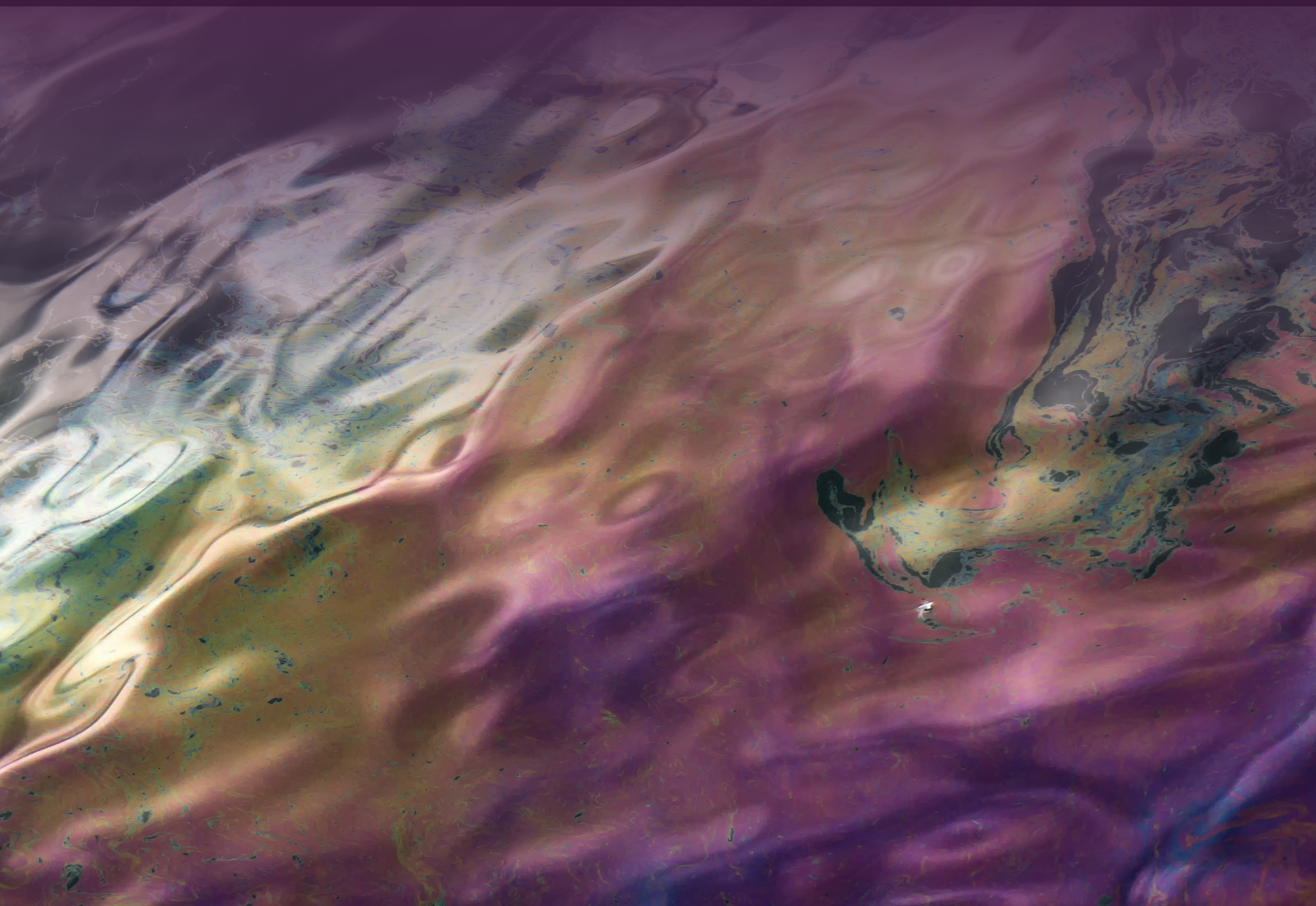
REPORT

The Royal Society of Canada Expert Panel:

The Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments

November 2015

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Dr. Michel Boufadel
Dr. Bing Chen
Dr. Julia Foght
Dr. Peter Hodson
Dr. Stella Swanson
Dr. Albert Venosa



Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments

An Expert Panel Report prepared at the request of
the Royal Society of Canada
for the Canadian Energy Pipeline Association
and the Canadian Association of Petroleum Producers

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November 2015

ISBN: 978-1-928140-02-3

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RSC: EPR 15-1

The report should be cited as follows:

Lee, Kenneth (chair), Michel Boufadel, Bing Chen, Julia Foght, Peter Hodson, Stella Swanson, Albert Venosa. (2015). Expert Panel Report on the Behaviour and Environmental Impacts of Crude Oil Released into Aqueous Environments. Royal Society of Canada, Ottawa, ON. ISBN: 978-1-928140-02-3

The opinions expressed in this report are those of the authors and do not necessarily represent those of the Royal Society of Canada or the opinion or policy of the Canadian Energy Pipeline Association or the Canadian Association of Petroleum Producers.

The Royal Society of Canada Expert Panels

The Expert Panels of the Royal Society of Canada (RSC) are central to the society since its mission includes a charge to *"…advance knowledge, encourage integrated interdisciplinary understandings and address issues that are critical to Canadians"*.

RSC Expert Panels provide independent, timely and authoritative insights and advice to governments, industry, non-governmental organizations, and citizens. Topics for expert panels are selected, in part, on the benefit they are likely to receive from a critical assessment of existing knowledge from a wide range of disciplinary and sectorial perspectives. While the Society does not shy away from controversial topics, it does insist that there must be room for critical, balanced, scientific analysis that makes it possible to achieve a consensus document from a diverse group of experts. Topics where differences in opinion are based on belief systems that are not founded in informed science are not be appropriate for an RSC Expert Panel.

Not surprisingly, RSC Expert Panels are often commissioned (and funded) by organizations that may have a strong interest in the conclusions of the report. However, for a variety of reasons, they not only want to receive a report that is independent, balanced and objective, but they want that report to be seen to be so by other stakeholders.

To ensure that this is the case, the RSC Committee on Expert Panels has developed a rigorous set of procedures[1] that guide their work. These procedures include:

1. **Defining the Terms of Reference (TOR):** Other than writing a cheque, this is the only part of the Expert Panel process where the commissioning organization has significant input. The RSC 'Committee on Expert Panels' works with the funder to develop draft TOR describing the charge to the panel, ensuring that it is neither too narrow, nor too broad, and, in particular, that it does not direct the panel towards a pre-determined conclusion. Before the TOR are approved, they are discussed with experts from the relevant stakeholder communities and, if appropriate, modifications are made before final approval by the funder and the RSC.
2. **Selection of Panel members.** Panel selection is the responsibility of the Committee on Expert Panels and its Oversight Committee, and does not consult with the commissioning organization. Explicit effort is made to ensure diversity of both expertise and perspectives (bias) in the subject area. Prospective panelists are interviewed and complete 'conflict of interest declarations' before being selected. Panelists are not reimbursed for the considerable time and effort that they contribute to the work of RSC Expert Panels.
3. **Deliberations of the Panel and Report Preparation.** Panel deliberations are 'in camera', with the exception of planned public hearings that are open to all. The panelists decide on the content of their submitted report and write it themselves. They are identified as the authors of the report (not the RSC), since RSC Expert Panels are reports <u>to</u> the RSC not <u>from</u> the RSC to the sponsor.
4. **Selection of Reviewers.** Selection of a Peer Review Monitor and the Peer Reviewers is also the responsibility of the Committee on Expert Panels and its Oversight Committee. The monitor manages the Peer Review process and is selected to ensure they have sufficient expertise to be comfortable in the content area, but have no conflict of interest or perception of bias. The peer review monitor works with the Panel Chair to ensure that all feedback from reviewers is carefully assessed and that appropriate revisions are made.
5. **Public Release of the Report.** The report is released to the media and public (on the RSC website[2]). No opportunity is given to the commissioning organization to request modifications of the report or its recommendations. However, the commissioning organization does receive a copy

[1] *See http://www.rsc.ca/en/expert-panels/information-about-expert-panels*
[2] *http://www.rsc.ca/en/expert-panels/rsc-reports*

of the report a few days before it is released so they have an opportunity to prepare responses to its content by the time the report is publically released.

6. **Ownership of the report.** The report belongs to the RSC. However, the RSC typically gives written permission to the panelists / authors to rework the document and submit portions of it to academic journals or other publications if they wish to do so.

Organizations or individuals interested in discussing opportunities for the RSC to carry out an Expert Panel on a topic of interest to them should contact the Chair of the Committee on Expert Panels at epsec@rsc-src.ca.

Preface

Canadians are among the highest per capita consumers of oil in the world, equivalent to about 25 barrels – or about 4000 litres – of oil per person per year.

Canada is also one of the world's only developed economies that produces more oil than it demands for domestic consumption, currently about 1.5 times more (about 6000 L/person/yr). In recent years, the rate of oil production has been increasing by about 5% per year, primarily through the growth of Alberta's oil sands.

To meet both domestic and international demand, the oil must be moved by pipeline, rail, tanker trucks or ship from where it is recovered to where it will be refined and ultimately used. In recent years, the energy industries have been developing plans and seeking permission to expand or modify their transportation networks, especially those involving pipelines. Keystone XL, Northern Gateway, Trans-Mountain, Line 9 Reversal and Canada East are names of pipeline projects that have regularly been a regular feature in the news.

Hot-button topics at the forefront of those concerned with these pipeline projects include questions about the consequences of accidental spills of crude oil into aquatic ecosystems. *Do we have sufficient knowledge about how crude oils behave when released into fresh waters, estuaries or oceans to develop effective strategies for spill preparedness, spill response and remediation? What are the gaps in knowledge and how should research insights inform policies, regulations and practices in this area?*

Among the conditions for the approval of the Gateway project, the National Energy Board required the applicants to establish '*a research program regarding the behavior and cleanup (including recovery) of heavy oils spilled in freshwater and marine aquatic environments' (Condition 169).*[3] In mid 2014, the Royal Society of Canada's (RSCs) Committee on Expert Panels was approached about carrying out an independent, arm's length assessment of the state of the science in this area.

Since the prospective funders of this panel (Canadian Energy Pipeline Association (CEPA) and the Canadian Association of Petroleum Producers (CAPP)) might be perceived to have a strong interest in the outcome of the work, the Committee on Expert Panels was especially rigorous in following its procedures (see previous pages) to ensure an independent, balanced and objective report.

CEPA and CAPP suggested the initial Terms of Reference, and were receptive to changes in those terms following RSC preliminary consultation with diverse experts. Neither CEPA nor CAPP (or their membership) had any input into the selection of panelists or reviewers, or into the recommendations of this panel.

The RSC thanks CEPA and CAPP for their support of this project and appreciates their professional approach that let us go about our work without interference of any kind.

We wish to thank the Panel Chair, Dr. Ken Lee and his fellow panelists (listed on the next page) for volunteering their time and expertise to prepare this report. This comprehensive and high quality report did not emerge without exceptional effort. Thank you!

We also want to thank the Peer Review Monitor, Dr. Robie Macdonald, FRSC and eight expert reviewers (listed on the next page), who provided extensive comments, criticisms and suggestions on the first draft of this report. The additions and clarifications that resulted from their feedback significantly added to the quality of the document.

[3] *Report of the Joint Review Panel for the Enbridge Northern Gateway Project (Dec 19, 2013) Conditions 169, 170, and 193* http://gatewaypanel.review-examen.gc.ca/clf-nsi/hm-eng.html

Finally, a special thank you to Russel MacDonald from the RSC office in Ottawa and Lisa Isaacman from Bonnyville who provided administrative and editorial support for the work of the panel and to the members of the Committee on Expert Panels and its Oversight Committee that were involved in selecting the panelists and reviewers.



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Support of the Work of the Panel

We are grateful to the following individuals:

Christopher Stone, (Calgary, Alberta) for his assistance in compiling references and identifying prospective panellists and reviewers.

Lisa Isaacman, (Bonnyville, Alberta) for her administrative work with the panel and editorial work on the report

Russel MacDonald, (Officer, Expert Panels & the College, the Royal Society of Canada, Ottawa, Ontario) for his assistance in managing the funds, helping with logistics, taking notes and producing the final report.

Peter Christie (Science Writer, Kingston, Ontario) for his assistance with some critical sections of the report.

Peer Reviewers

The Royal Society of Canada would like to acknowledge and sincerely thank the Peer Review Monitor and eight peer reviewers who provided valuable, detailed input into the first draft of this report. The following reviewers have permitted the RSC to release their names:

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The peer reviewers provided many very constructive comments, but they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before it was released. The identification of reviewers is done to recognize them for their valuable contributions and does not imply that they endorse the report or agree with its content. Responsibility for the final content of this report rests entirely with the Panel.

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Table 7.5 Representative examples of oil types, applied response methods, performance and environmental impacts of some major oil spills in Canada and the U.S.

Oil Spill Case	Oil Type	Date	Amount (US gallon)	Responses and Performance	Key Impacts	References
Nova Scotia Uniacke G-72 Oil Spill, Nova Scotia, Canada	Mud, gas and condensate	February 22, 1984	126,000	• Well crews evacuated • No immediate response • Well recapped 10 days later	• Strong hydrocarbon odour was present as far as 10 km away • Oiled seabirds and seals were observed • No evidence of condensate on the shoreline	Gill et al. (1985)
Exxon Valdez Oil Spill, Alaska, USA	Crude oil	March 24, 1989	11-38 million	• Controlled burning (with ship and boom) - 113,400 L of oil reduced to 1,134 L of removable residue • Mechanical cleanup (with boom and skimmer) - only 10% oil recovered • Skimmer: low efficiency (thick oil, heavy kelp, plenty of permanent container, bad weather, etc.) • Chemical dispersants ineffective due to lack of wave energy • Shoreline washing • Bioremediation of shorelines	• Immediate effects - the deaths of 100,000 to as many as 250,000 seabirds, at least 2,800 sea otters, and many other animals • Long-term effects: more losses of species than expected • Bioremediation was somewhat effective in accelerating biodegradation as a cleanup option	Morris and Loughlin (1994); Boehm et al. (2014)
Pine River Oil Spill, British Columbia, Canada	Light crude oil	August 1, 2000	260,400	• 118,800 gallons removed from the river • Vacuum oil and set up containment booms of 12, 24 and 28 miles from the rupture • 119,560 gallons removed from soil • Removal of large woody debris from river channel due to it being coated with oil	• Extensive mortality of fish and some wildlife • Water supply to the District of Chetwynd was ceased and the use of many groundwater wells nearby the river was discontinued • Disruption of the river channel and destruction of fish habitat by seasonal flooding following the removal of woody debris that stabilized the river morphometry	Anderson and Schwab (2012); Chung et al. (2012)
Terra Nova Oil Spill, Newfoundland, Canada	Waxy crude	November 2004	43,650	• 5% oil recovered	• An estimated 10,000-16,000 direct kills of birds	McGrath (2014)

EXHIBIT 6

An official website of the United States government

United States Environmental Protection Agency

MENU

Search EPA.gov

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Site Location:
U.S. Highway 6 and Consumers Road
Helper, UT 84526
response.epa.gov/HelperJadeEnergyOilSpill (https://response.epa.gov/HelperJadeEnergyOilSpill)
NRC#: 1443305

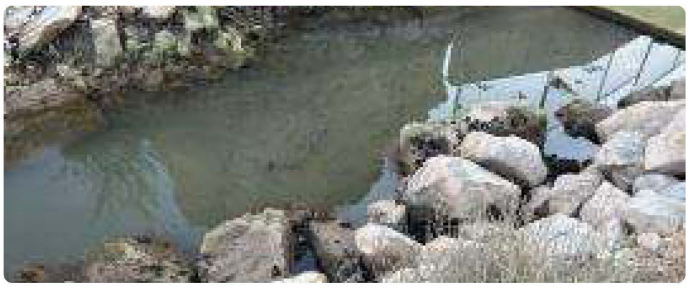
On September 21, 2025, at approximately 2:30 AM, two crude oil tanker trucks collided on U.S. Highway 6/191 near Helper, Utah.

Each truck was carrying roughly 175 barrels (7,350 gallons) of waxy Uintah Basin crude oil. One truck caught on fire due to the oil being transported at high temperatures for ease of handling. An estimated 10-25 barrels (420-1,050 gallons) discharged into Consumers Wash, leading to the Price River.

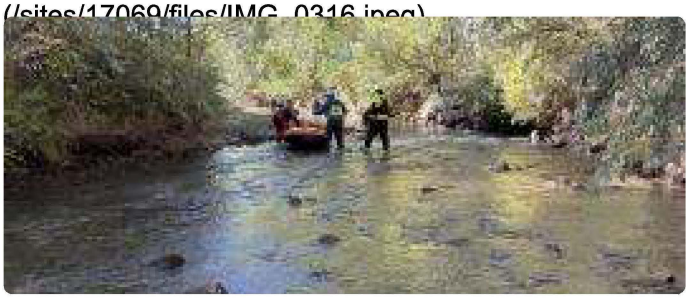
The river downstream of the Site has several agricultural diversions, including the Carbon Canal and the Price/Wellington Canal. Both canals were impacted by crude oil. The Scofield Reservoir Dam, upstream of Helper, was notified and asked to reduce the river flow to allow for crude oil recovery and prevent further migration.

EPA, state, and county personnel are conducting recovery efforts to remove oil from the river.


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(/sites/17069/files/IMG_0377.jpeg)

Resources

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Attorneys for Plaintiff General Star Indemnity Company

IN THE UNITED STATES DISTRICT COURT
DISTRICT OF UTAH

GENERAL STAR INDEMNITY COMPANY, Plaintiff, v. JADE ENERGY, LLC, Defendant.	**COMPLAINT FOR DECLARATORY JUDGMENT** Civil Case No. 2:25-cv-01022 Judge

Plaintiff General Star Indemnity Company ("General Star") brings this Complaint for Declaratory Judgment in this Court pursuant to 28 U.S.C. § 1332(a) and 28 U.S.C. § 2201 against Defendant Jade Energy, LLC ("Jade Energy"). General Star alleges on knowledge, information, and belief as follows:

NATURE OF THE ACTION

1. General Star brings this action to obtain a judicial determination and declaration that Excess Liability Policy No. IXG78856A, which General Star issued to Jade Energy (the "Excess Policy"), does not afford coverage for the costs to clean up an oil spill that occurred on September 21, 2025 (the "Oil Spill"), for the reasons set forth below. A true and correct copy of the Excess Policy is attached as Exhibit A.

2. By email of October 1, 2025, Jade Energy's broker advised General Star of the Oil Spill, which was the result of a collision between an oil tanker truck purportedly operated by Jade Energy and another oil tanker truck operated by non-party Summit Oil. A copy of the October 1, 2025 first notice of loss is attached as Exhibit B.

3. General Star seeks a judicial determination that no coverage is available under the Excess Policy for the Oil Spill because the Excess Policy's Total Pollution Exclusion bars coverage.

4. An actual and justiciable controversy has arisen and now exists relating to the parties' respective rights, duties, and obligations under the Policy.

PARTIES

5. Plaintiff General Star Indemnity Company is a corporation organized and existing under the laws of the State of Delaware, with its principal place of business located in the State of Connecticut.

6. Defendant Jade Energy is a limited liability company, organized and existing under the laws of the State of Utah, with its principal place of business located in

the State of Utah. According to filings with the Utah Department of Commerce, Jade Energy has only one member, B. Savage, who is a resident of the State of Utah.

JURISIDCTION AND VENUE

7. This is an action for declaratory judgment pursuant to the Federal Declaratory Judgment Act, 28 U.S.C. §§ 2201 and 2202, and Rule 57 of the Federal Rules of Civil Procedure, for the purpose of determining an actual and justiciable controversy between the parties.

8. This action is ripe for adjudication.

9. This Court has jurisdiction over this action pursuant to 28 U.S.C. §§ 1332. There is complete diversity of citizenship between Plaintiff General Star, a citizen of Delaware and Connecticut, and Defendant Jade Energy, a citizen of Utah. The amount in controversy exceeds the sum of $75,000, exclusive of interest and costs. Specifically, Jade Energy seeks coverage under the General Star Excess Policy, which is excess of at least $2 million in underlying insurance. Additionally, Jade Energy has notified General Star that the initial clean-up cost estimates for the Oil Spill may exceed $4 million.

10. Venue is proper in this Court pursuant to 28 U.S.C. § 1391, as a substantial part of the events or omissions giving rise to this action occurred in this judicial district.

FACTUAL ALLEGATIONS

The Oil Spill

11. Jade Energy has notified General Star of the following facts concerning the Oil Spill.

12. On September 21, 2025, at approximately 2:30 am, a truck purportedly operated by Jade Energy was traveling on Highway 6 in Helper, Utah, when it was involved in a collision with a truck operated by non-party Summit Oil.

13. At the time of the accident, both the Jade Energy truck and the Summit Oil truck were hauling crude oil.

14. As a result of the collision, some or all of the oil from each vehicle was released onto the roadway, which then leaked into the surrounding ravines and into a nearby navigable waterway, the Price River.

15. Jade Energy and Summit Oil are currently sharing in the costs to clean up the Oil Spill.

The Excess Policy

16. General Star issued Excess Liability Policy No. IXG78856A to Jade Energy for the Policy Period of June 1, 2025 to June 1, 2026.

17. The Excess Policy has an aggregate limit of liability of $4 million, excess of a $2 million primary auto liability and commercial general liability policy.

18. Subject to its terms, conditions, and exclusions, the insuring agreement of the Excess Policy provides: "**We** will indemnify the insured for **ultimate net loss** in excess of the total of the limits of **underlying insurance** that is covered by both the **controlling underlying policy** and this policy. **We** will not indemnify the insured, however, for any such **ultimate net loss** incurred in connection with any event, claim or suit that is subject to a sublimit in any **underlying insurance**. Coverage under this policy

will not attach until the limits of all **underlying insurance** have been paid in full and all such applicable limits of the **underlying insurance** have been exhausted." Excess Policy, Section I.1.

19. Endorsement 12 to the Excess Policy is titled, "Exclusion—Total Pollution." The Total Pollution Exclusion provides as follows.

> 1. This policy does not apply to any damages for which the insured is legally liable, or loss, **costs** or expenses arising out of, resulting from, caused by or contributed to by:
>
> a. The actual, alleged or threatened discharge, dispersal, seepage, migration, release or escape of **pollutants** at any time.
>
> b. Any loss, **costs** or expense arising out of any:
>
> (1) Request, demand, or order that any insured or others test for, monitor, clean up, remove, contain, treat, detoxify or neutralize, or in any way respond to, or assess the effects of pollutants; or
>
> (2) Claim or suit by or on behalf of a governmental authority or others for damages because of testing for, monitoring, cleaning up, removing, containing, treating, detoxifying or neutralizing, or in any way responding to, or assessing the effects of **pollutants**.
>
> Any actual or alleged: breach of duty, negligent act, error or omission, of any insured or of any person for whose acts any insured is legally liable which results in damages, loss, **costs** or expense as described in a. or b. above.
>
> 2. This policy does not apply to any damages for which the insured is legally liable, loss, **costs** or expenses arising out of, resulting from, caused by or contributed to by **pollutants** regardless of whether the **underlying insurance** affords coverage for such damages, loss, **costs** or expenses.
>
> **Pollutants** means:

(a) Any solid, liquid, gaseous or thermal irritant or contaminant, including smoke, vapor, soot, fumes, acids, alkalis, chemicals and waste. Waste includes material to be recycled, reconditioned or reclaimed; and

(b) Any other substance defined as, treated as or considered to be **pollutants** by the **underlying insurance**.

Id., Endorsement 12.

20. Jade Energy provided notice to General Star of the Oil Spill on October 1, 2025, and sought coverage under the Excess Policy for the clean-up costs associated with the Oil Spill.

21. General Star denied coverage for the Oil Spill based on the Excess Policy's Total Pollution Exclusion.

22. General Star understands that Jade Energy disputes General Star's coverage position.

COUNT I

For a Declaration that the Excess Policy Does Not Afford Coverage for the Oil Spill.

23. General Star repeats and incorporates the allegations in Paragraphs 1 to 24 of this Complaint.

1. The Total Pollution Exclusion bars coverage for any "damages for which the insured is legally liable, or loss, **costs** or expenses arising out of, resulting from, caused by or contributed to by" pollutants, including the "actual, alleged or threatened discharge, dispersal, seepage, migration, release or escape of **pollutants** at any time" or a "[r]equest, demand, or order that any insured or others test for, monitor, clean up,

remove, contain, treat, detoxify or neutralize, or in any way respond to, or assess the effects of pollutants." Excess Policy, Endorsement 12.

2. Crude oil is a "pollutant" because it is a "liquid contaminant."

3. The September 21, 2025 truck collision resulted in "discharge" or "dispersal" of the crude oil, and Jade Energy is sharing in the cost to clean up the crude oil.

4. The Total Pollution Exclusion in the Excess Policy bars coverage for the Oil Spill, including any liability of Jade Energy for clean-up costs.

5. Accordingly, General Star is entitled to a declaration that the Excess Policy does not afford coverage for the Oil Spill.

PRAYER FOR RELIEF

General Star prays for relief as follows:

(a) A declaration that the Excess Policy does not afford coverage for the Oil Spill;

(b) An award of costs in favor of General Star and all other relief that the Court deems just and proper.

Respectfully submitted this 7th day of November, 2025.

LITCHFIELD CAVO LLP

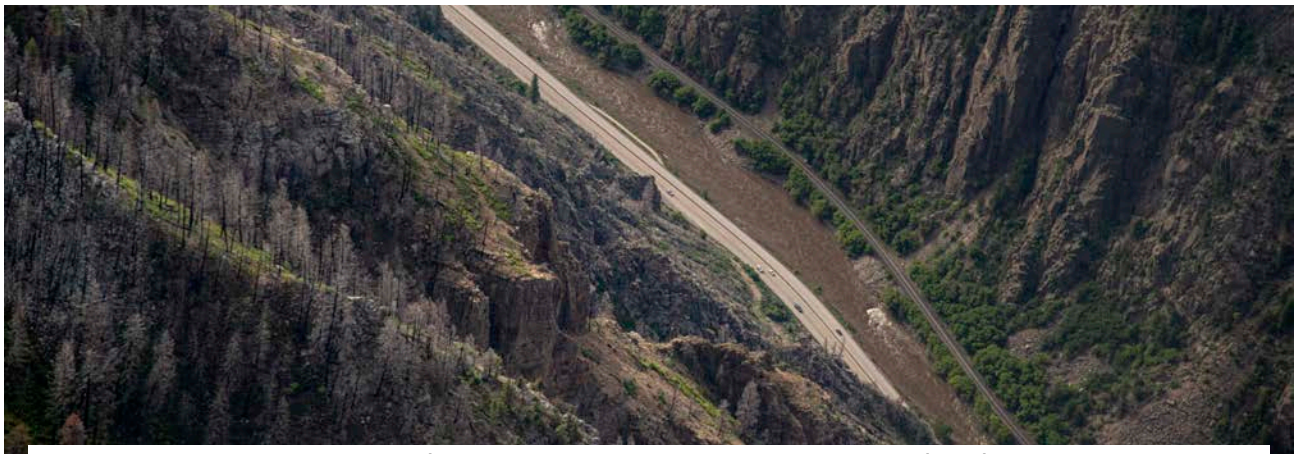
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EXHIBIT 8

COLORADO NEWSLINE



The Canyons: Oil and water could mix in Colorado River country known for its beauty, fragility

Accident risks for proposed oil trains could be highest in a rugged region that has seen numerous derailments

BY: **CHASE WOODRUFF** - JUNE 28, 2023 4:00 AM

Traffic flows along Interstate 70 through the burn scar of the Grizzly Creek Fire in Glenwood Canyon east of Glenwood Springs, June 9, 2023. The railroad is seen along the right side of the river. (William Woody for Colorado Newsline)

BURNS, Colo. — Beneath the limestone cliffs, the trunk of a lone, dead lodgepole pine stuck straight up from the brush along the riverbank, looming over a remote stretch of the Colorado River in northern Eagle County.

Inside the train cars passing by on the opposite side of the river, a voice came over the loudspeaker, pointing out to passengers the dark shape perched inside the nest atop the barren tree.

"The two bald eagles are gone, but that's one of the younger ones that hatched this year," the Amtrak conductor said. "They won't get their crown of white feathers on top of their head until they're almost a year and a half old — they look like giant crows, really, the younger ones. Maybe we'll see mom and dad fishing down here in a little while."

No part of the 51-hour journey between Chicago and Oakland is more vital to the appeal of Amtrak's California Zephyr than the 100-mile segment between



This is Part 3 of **Down the Line**, a Newsline series tracing the route that eastbound oil trains from the proposed Uinta Basin Railway in Utah could soon take through western and central Colorado.

Part 1: The Valley

Part 2: Boomtowns

Part 3: The Canyons

Part 4: Headwaters

Part 5: The City

stops in Glenwood Springs and Granby. Few passengers opt for the Zephyr because it's an efficient mode of cross-country travel; they're in it for the scenery, and the high country of the central Rocky Mountains provides that in abundance.

Click here for an overview of "Down the Line."

The Dotsero Cutoff, as this part of the Union Pacific's Central Corridor is known, became in 1934 the last major segment of the current route to be completed. It ended a 75-year struggle by Colorado leaders to establish a relatively direct east-to-west rail route over the Rockies to Utah, finally eliminating the southward detour to Pueblo and the Royal Gorge that had added nearly 200 miles to the journey between Denver and Salt Lake City.

With Union Pacific's closure of the Tennessee Pass line to the southeast in 1997, the Dotsero Cutoff became the only way to travel from the Western Slope to the Front Range by rail. It's the route that as many as five fully loaded, two-mile-long crude oil trains from Utah's Uinta Basin could soon take on their way to refineries in Texas and Louisiana, drastically increasing the flow of hazardous materials on some of the most rugged stretches of railroad track in the country.

Down the Line: The Canyons

Click on the links below to navigate to each section.

Glenwood Canyon | Gore Canyon | Byers Canyon

The project, backed by a partnership between seven Utah county governments and private industry, has received several key approvals from the Biden administration, despite mounting protests from Colorado officials. The railway's backers have signaled they will soon apply for $2 billion in tax-exempt Private Activity Bonds that must be approved by the U.S. Department of Transportation.

By the time eastbound trains pass through Glenwood Springs, they've already gained nearly 2,000 feet in elevation since crossing the Colorado-Utah border, and they will gain roughly 3,000 more as they continue their charge upwards through the Colorado River Valley, nearly as far as the river's headwaters in Rocky Mountain National Park.

After turning to the northeast at Dotsero, leaving Interstate 70 behind, the Central Corridor mainline winds through narrow gorges and sensitive wetlands along little-traveled dirt roads, and

even into remote corners of wilderness where there are no roads at all. Amtrak conductors, pulling double duty as tour guides, tell passengers of the only two ways to pass through a four-mile stretch of Gore Canyon southwest of Kremmling: in comfort on the California Zephyr, or over the dangerous Class V rapids on the Colorado River below.

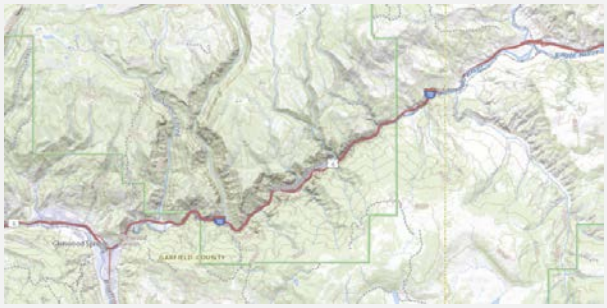
This was the region where the historic Denver & Rio Grande Railway, which ruled Colorado's railroads for over a century before being acquired by the Union Pacific in 1996, earned its boastful motto of "Through the Rockies, Not Around Them." And it's where many Coloradans fear the Uinta Basin Railway's crude oil trains would be most likely to cause an accident.



Passengers on Amtrak's California Zephyr sit in the sightseer lounge on June 5, 2023. (Chase Woodruff/Colorado Newsline)

A derailment or spill in this region could be disastrous for communities and ecosystems along the river, the railway's opponents say, especially in an era of worsening impacts from climate change. The grandeur of these mountain vistas goes hand in hand with their vulnerability, and many of them are more at-risk than ever — even before a daily deluge of crude oil trains is added to the mix.

"With the great beauty and awe of these sheer cliffs, they tend to crumble," said Jonathan Godes, a City Council member and former mayor of Glenwood Springs. "It's a very fragile place, as we've seen over just the last several years."



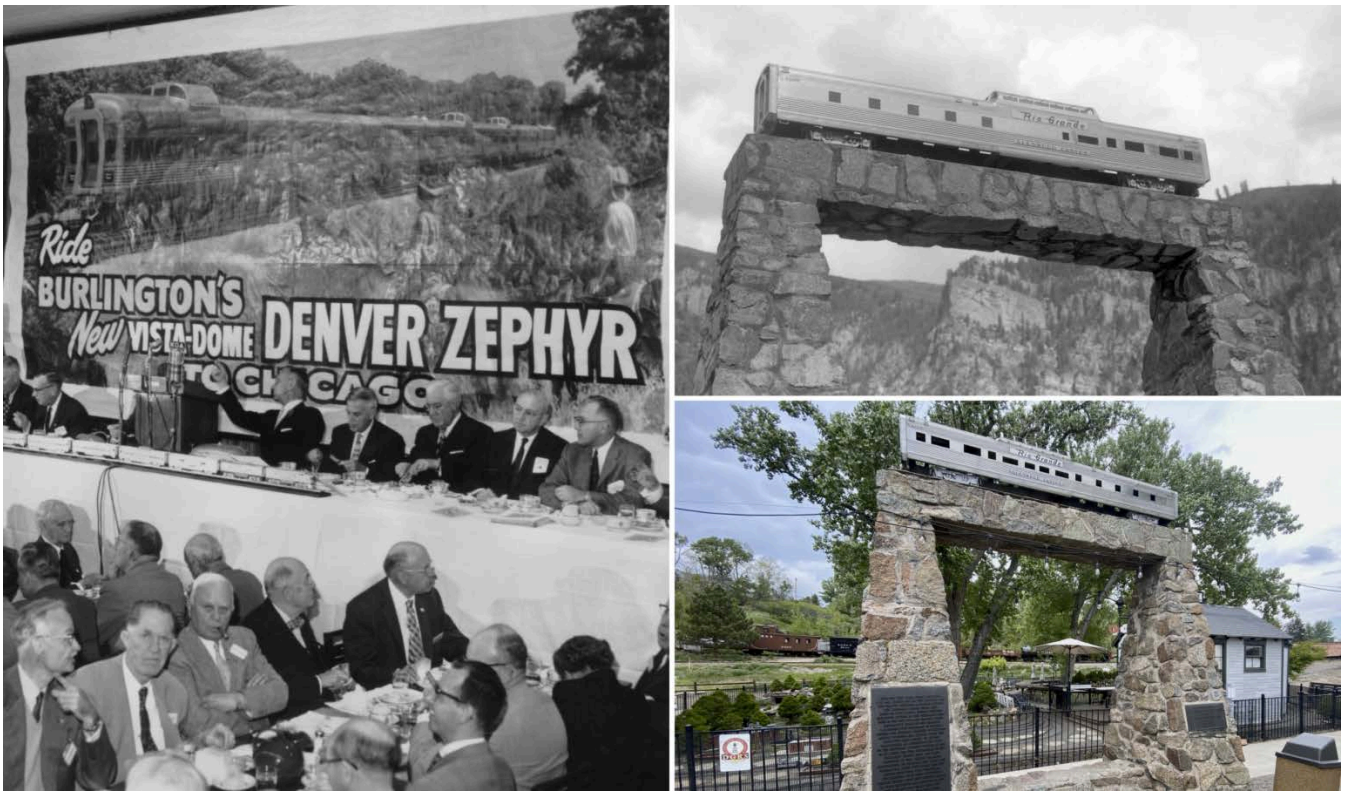
📍 ***Mile 124: Glenwood Canyon***

'Incredibly problematic'

General Motors executive Cyrus Osborn was traveling through Glenwood Canyon on a new diesel locomotive his company had built for the Denver & Rio Grande Railway on July 4, 1944, when the idea came to him: a passenger car with a domed roof that would allow tourists traveling the Rockies by rail to take in the sights.

The first California Zephyr train rolled through the canyon five years later with five gleaming steel Vista-Dome cars in tow, inaugurating a railroading tradition that lives on today in the domed sightseer lounges still offered on the modern-day Zephyr and six other Amtrak passenger lines. So instantly iconic were the Vista-Domes that in 1950 the Denver & Rio Grande erected a monument in Glenwood Canyon commemorating the site where Osborn had his vision, and for decades a scale replica of the silver sightseeing coach sat atop a stone arch by the Colorado River near Grizzly Creek.

But today the monument sits among the other relics in the yard at the Colorado Railroad Museum in Golden. It was evicted in the late 1980s, when crews building the final section of I-70, after decades of planning and design, finally entered the canyon.



Inspired by the scenery in Glenwood Canyon, Cyrus Osborn's Vista-Dome inaugurated a railroad craze for sightseeing lounges, like the one pictured at left at a 1956 promotional event in Denver. A monument, top right, marking the spot of Osborn's inspiration stood in Glenwood Canyon for a decade but was evicted ahead of Interstate 70 construction in the late 1980s and is now housed at the Colorado Railroad Museum in Golden, bottom right. (Denver Public Library Special Collections, Z-6019 & OP-11050, Chase Woodruff/Colorado Newsline)

Opened to traffic in 1992, the 12.5 miles of tunnels, bridges, viaducts and retaining walls between Dotsero and Glenwood Springs were some of the last of the more than 40,000 miles of interstate envisioned by the Federal-Aid Highway Act of 1956, and, at $40 million per mile, some of the most expensive.

Nationally, the project marked "the completion of the original U.S. interstate highway system," federal officials declared. In western Colorado, it symbolized the final victory of cars and trucks over the iron horses that had first steamed into the Colorado River Valley a century earlier.

For the 2,000-foot rock walls of Glenwood Canyon, though, a century passes in the blink of an eye. The Colorado River has been carving through them, inch by inch, for over three million years — a process that neither the railroad nor the interstate could ever hope to stop.

Rockfalls and washouts have long wreaked havoc on any form of transportation attempted through the canyon. The dirt paths and two-lane state roads that preceded the interstate's construction were some of Colorado's most dangerous. Since 1976, at least 21 train accidents reported to the Federal Railroad Administration have occurred within the canyon's boundaries.



Traffic flows along Interstate 70 through the burn scar of the Grizzly Creek Fire in Glenwood Canyon east of Glenwood Springs on June 9, 2023. (William Woody for Colorado Newsline)

Rocks on the track were to blame for the derailment of a California Zephyr train in Glenwood Canyon in 1968, and a "heavy build-up of snow on the track" caused an Amtrak derailment on Christmas 1988. A train hauling 14,000 tons of coal derailed near Grizzly Creek due to broken spikes in 2004. The partial collapse of a tunnel wall just east of Glenwood Springs caused another Union Pacific freight train to derail in May 2017.

But a new era of Glenwood Canyon dangers began with back-to-back disasters in 2020 and 2021. First, the Grizzly Creek Fire scorched more than 32,000 acres in and around the canyon during what became by far Colorado's worst wildfire season on record. A year later, heavy rainfall triggered mudslides in the fire's burn scar, sending heavy debris flows plummeting down its cliffs and into the river below and closing I-70 and the railroad for weeks.

Cleanup and repair costs after the 2021 mudslides ran into the tens of millions of dollars, and Gov. Jared Polis' administration has asked the federal government for a total of up to $116 million for projects that would mitigate the risks of similar damage in the future.

For many people in Colorado, the Grizzly Creek Fire and its aftermath became a potent symbol of the dangers and disruptions the state faces as climate change worsens. Now, for many of those Coloradans, the fragile Glenwood Canyon epitomizes the additional risks posed by the Uinta Basin Railway – which would not only increase heavy freight traffic and hazardous-materials shipments through the canyon but also help fuel the very climate crisis that's putting it under stress in the first place.



Muddy tracks and equipment are pictured from the rear of an Amtrak train traveling through Glenwood Canyon on June 5, 2023. (Chase Woodruff/Colorado Newsline)

“It’s incredibly problematic, running 10 miles’ worth of toxic waxy crude through some of the most sensitive and fragile and dangerous territory, possibly in the country,” said Godes.

In some places, the debris flows in August 2021 buried the Union Pacific tracks under several feet of mud. Less severe flows and washouts have continued to impact rail operations through the canyon, including on two separate occasions last month.

“Fortunately, there wasn’t a train going through, but it completely buried that line,” Eagle County Commissioner Matt Scherr said of the 2021 mudslides. “And at this point, if you up the volume of rail traffic to the extent they’re talking about, it’s just a much higher likelihood that any landslide that does happen is going to hit a train.”



A washout covered railroad tracks near Glenwood Springs under a layer of mud on May 2, 2023. (City of Glenwood Springs)

"We are aware of the hazards of mudslides in Colorado, which impacts both rail and highways, and we are working closely with the Colorado Department of Transportation to mitigate risks," a Union Pacific spokesperson wrote in an email.

In April, some of Colorado's top elected officials chose a spot beside the river in Glenwood Canyon for a press conference in which they denounced the railway project in some of their strongest language yet. Standing beside an oil drum representing one of the roughly 315,000 barrels of crude that could pass through the canyon daily, Democratic U.S. Sen Michael Bennet said approval of the project "would be a black mark on the president's environmental record."

"This train has no business bringing this oil from Utah through Colorado, period," Bennet said. "Anybody who has spent any serious time in this canyon understands what the risks really are — what these mudslides really look like, what these fires really look like."

'Elevated risk factors'

There were no mudslides or blizzards in Glenwood Canyon on the night of Jan. 15, 1909 — just a busy railroad, two train crews speeding towards their destinations, and a system that lacked standardized safety measures and regulations.

By the time the crew of the westbound Denver & Rio Grande passenger train came around the bend near Spruce Creek and saw the oncoming freight train, it was too late. The passenger train's

engineer had misjudged the time by 10 minutes, and the two trains collided head-on in a fiery crash.



AWFUL WRECK ON D. & R. G. ROAD

HEAD-ON COLLISION OF PASSENGER AND FREIGHT TRAIN AT DOTSERO.

TWENTY-ONE ARE DEAD

THIRTY-FOUR WERE INJURED, SOME OF WHOM WILL NOT RECOVER.

Denver.—A Republican special from Glenwood Springs Saturday night says: With twenty-one known to be dead and thirty-four injured, some fatally, the collision of passenger and freight trains on the Rio Grande at Dotsero last night, ranks second in horror only to the Adobe and Eden wrecks on the same line.

At Dotsero bodies were mangled beyond recognition and cannot be identified, but at Adobe they were burned and at Eden swept away by a flood.

The 1909 train wreck near Dotsero was one of the deadliest accidents in Colorado railroad history. (Colorado State Library)

The Dotsero train wreck, which killed 21 people, injured more than 30 others and made headlines all around the country, remains one of the deadliest rail accidents in state history. It was one of a series of disasters in Colorado and across the country that added up to a crisis of railroad safety around the turn of the 20th century, as traffic on the rails continued to rise in the absence of accurate timekeeping, reliable equipment and adequate signaling systems.

Public outcry over such wrecks helped lead to the establishment of the Colorado State Railroad Commission in 1907. In its second biennial report to the state Legislature, issued in the wake of the Dotsero wreck, the commission decried "the appalling loss of life and property in collisions" plaguing the state. The mounting death toll was, the commission wrote in a special safety report that year, "due, in part, to the heavy volume of business being done by the roads of this state, and the further fact that many of our mountain roads have long, heavy grades, and not infrequently the air pumps or brakes, for some unaccountable reason, fail to respond at the critical period."

Overcoming legal challenges brought by railroad companies against its constitutionality, the Railroad Commission led the charge to improve train safety in Colorado. Its work proved successful and popular enough that in 1914 the Legislature expanded the body and renamed it the Public Utilities Commission, granting it the authority to regulate the electric, gas, water and streetcar industries the way it had the railroads.

Technology and regulation have steadily improved rail safety over time, and the American Association of Railroads, an industry lobby group, calls this the safest period in the history of railroading. Industry groups are especially keen to point out data showing that transporting hazardous materials by rail is significantly safer than doing it by truck.

> This train has no business bringing this oil from Utah through Colorado, period.
>
> *– U.S. Sen. Michael Bennet in April*

But a recent rise in longer, heavier trains in accordance with an industry practice known as "precision scheduled railroading" has prompted new safety concerns, and critics fault the rail industry for dragging its feet on implementing measures like modern braking systems and higher

standards for tank cars. U.S. Transportation Secretary Pete Buttigieg, in a letter to Norfolk Southern following the February train derailment and chemical fire in East Palestine, Ohio, urged an end to "vigorous resistance by your industry to increased safety measures."

Among the rail industry's critics, the East Palestine incident and other subsequent derailments have raised fears that the bill could be coming due on decades of corporate consolidation and investor pressure on railroads to cut costs and maximize profits. Such fears were also prevalent a decade ago, when a major increase in the amount of crude oil being shipped by rail resulted in dozens of reported derailments, spills, fires and explosions, leading environmental activists to launch campaigns nationwide against what they labeled "bomb trains."

Oil-by-rail shipments peaked at an average of over 1 million barrels per day in 2014, according to the U.S. Energy Information Administration, a surge that experts say was never likely to be permanent. A 2014 congressional report explained that the increase occurred after "rapid expansion of oil production … strained the capacity of existing pipelines," and accurately predicted that the crude shipments by rail would ebb as the "pipeline bottleneck" was eased. By last year, those shipments had fallen to an average of about 268,000 barrels per day.

That makes the Uinta Basin Railway different than many other oil-by-rail projects in the recent past, since there's no prospect of a conventional oil pipeline replacing it. For however long into the future drillers in eastern Utah are producing large volumes of waxy crude oil, federal regulators expect the railway would direct the vast majority of it through Colorado. At an estimated capacity of up to 315,000 barrels per day — more than was shipped by rail across the entire country in 2022, including imports from Canada — the project would make the Union Pacific route between the Kyune, Utah and Denver the nation's new oil-by-rail superhighway.

In a "downline analysis," the federal Surface Transportation Board predicted that Uinta Basin oil trains could, on average, cause a rail accident between Kyune and Denver once every 13 months. Accidents severe enough to cause a spill of up to 30,000 gallons of crude oil, regulators predict, will occur roughly once every five years.

But a coalition of 10 Colorado city and county governments argued in a legal brief earlier this year that those projections understate the true risk level. They cited federal data and an analysis by the Pipeline and Hazardous Materials Safety Administration that found that trains hauling crude oil tankers are "heavier in total, more challenging to control… (and) more prone to derailments when put in emergency braking."

"The Board neither disclosed nor analyzed these elevated risk factors, relying instead on apples-to-oranges national averages that are inapplicable to these longer, heavier trains," wrote the governments in a brief in support of a lawsuit filed by Eagle County and five environmental groups against the STB over its approval of the railway.



From left, Glenwood Springs Mayor Jonathan Godes, state Sen. Dylan Roberts, U.S. Rep. Joe Neguse, U.S. Sen. Michael Bennet and Colorado House Speaker Julie McCluskie participate in a press conference near Interstate 70 at the confluence of Grizzly Creek and the Colorado River to voice opposition to the Uinta Basin Railway project, April 7, 2023. (Chase Woodruff/Colorado Newsline)

Though Bennet and others in Colorado's congressional delegation have called on the Biden administration to halt the project, some railway opponents want state-level officials to take a more active role in opposing it. So far, opposition from Gov. Jared Polis' administration has been muted, though the governor, through a spokesperson, has expressed "concerns" about the project.

The state's Public Utilities Commission may have been established as a railroad watchdog, but today the industry makes up only a small part of its regulatory portfolio. Following federal legislation that abolished the Interstate Commerce Commission in 1995, "the PUC doesn't have as much authority as it did previously," an agency spokesperson wrote in an email. The agency denied repeated interview requests with state rail safety officials, citing a lack of "media training" among staff.

In the mid-2010s, state and local opposition in the Pacific Northwest successfully blocked a series of proposals that would have dramatically increased oil-by-rail shipments to West Coast refineries. The largest of those projects, a proposed rail terminal in Vancouver, Washington, would have generated roughly the same amount of oil-train traffic as the Uinta Basin Railway, but it was abandoned in 2018.

"We fortunately were able to defeat those, because the environmental and human health risks are just too great," said Kristen Boyles, a Seattle-based attorney with environmental group Earthjustice who worked to defeat the projects. "Which is why it's so frustrating to have had that history, and to have had that public outcry about the danger these oil trains pose, and have that sort of die down a little bit – and then, nope, it pops up again with the train in Utah."



📍 ***Mile 197: Gore Canyon***

'Undesired emergency'

As trains bound for Denver approach Gore Canyon from the southwest, Amtrak conductors point out another favorite landmark: the wreckage of several cars strewn about the steep rocky slope across the river. They tumbled hundreds of feet down from the cliffside road overhead decades ago, and recovery of them is too dangerous.

Around the next bend, the wreckage disappears, and so does the road. For the next four miles, the Union Pacific railroad travels along the river alone.

On a snowy night in November 2014, a westbound Union Pacific freight train had made it roughly halfway through this remote stretch when it "had rocks fall into train," according to the brief accident report filed later. Though only one car in the half-empty train jumped the tracks, the derailment and track damage closed the route for days.

It was the sixth train accident in Gore Canyon in the previous 16 years, according to safety records from the Federal Railroad Administration. The lead locomotive hauling a 99-car eastbound train derailed in November 1998 due to a "rock slide in face of train." Another rock slide near one of the canyon's tunnels derailed nine cars in 2005. The accident report filed after a six-car March 2000 derailment there simply states that the train "went into undesired emergency."



Railroad tracks through Gore Canyon southwest of Kremmling on June 12, 2023. (Chase Woodruff/Colorado Newsline)

Perhaps more than any other scenario, opponents of the Uinta Basin Railway are haunted by the thought of what could happen if an oil-train accident occurs in one of these remote mountain canyons.

“These are very difficult places to access quickly, which makes cleaning up a spill more dangerous,” said Kirk Klancke, president of the Colorado River Headwaters Chapter of anglers’ conservation group Trout Unlimited. “The biggest threat in a spill in any of these canyons besides access is going to be the fact that it's not just oil, which has a lot of cleanup procedures, it’s waxy crude.”

The Uinta Basin’s oil is known as “waxy” crude because of its high degree of paraffin wax, which gives it the consistency of shoe polish at room temperature. It comes out of the ground at higher temperatures and is typically stored in heated tanks before being transported.

In recent months, the railway’s proponents have accused critics of spreading “misinformation” about spill risks, claiming that the waxy crude would be transported “as a solid, not a liquid,” lowering the likelihood that large volumes could be spilled in the event of a derailment.

But in an interview, Keith Heaton, director of the Seven County Infrastructure Coalition, the public entity that has led the Uinta Basin Railway’s development to date, acknowledged that the project can’t guarantee that will always be the case.

"I don't know that I'm guaranteeing anything," Heaton said. "Our responsibility has been the planning and the permitting … I am not the expert on railroads, or petroleum, or any of those things."



A coal train travels along the Colorado River north of Gypsum in Eagle County on June 12, 2023. (Chase Woodruff/Colorado Newsline)

Relatively small amounts of the Uinta Basin's waxy crude are currently being transported by tanker trucks to one of several rail terminals along the existing Union Pacific railroad in central Utah, then shipped by rail out of state. These shipments began in 2013 using "coil-heated and insulated tank cars," according to the Utah Geological Survey. More recently, other Uinta Basin producers have shipped waxy crude in non-heated tank cars, allowing their contents to gradually solidify in transit before being reheated at their destination.

If the railway is built, whether or not Uinta Basin tank cars are heated and insulated will be up to the producers, rail operators and refineries that purchase the oil. No law or regulation would tie their hands, and the railway project's 3,600-page environmental impact statement doesn't address the issue at all.

"The economics of what happens with this after that is really up to the private side of the entity, and there's a number of different entities involved in all of this, as there is with any industry or business," Heaton said. "But yeah, we don't have anything that addresses that in any way, shape or form."

Even in cases where the oil is being shipped in non-insulated tank cars, outdoor temperatures will be a major factor. Heaton said that according to the SCIC's industry partners, the waxy crude loaded into a tank car can – "depending on ambient temperatures" – cool to below its 110-degree melting point in about five hours.

Communities along the downline route have sought more clarity from railway proponents on a number of issues relating to the waxy crude's transport, especially when it comes to how long it would take the 30,000 gallons of oil in each tank car to cool to a solid in the summertime heat.

"For us to feel some sort of assurance, just on that specific point ... there ought to be scientific data and understanding of what that is," Scherr said. "And that is only one of all the environmental risks that we're concerned about."

> It's a very convenient thing for them to say it's going to be solid, but that's not what the facts show.
>
> – ***Deeda Seed of the Center for Biological Diversity***

In the absence of any detailed answers, railway opponents are deeply skeptical of claims that the oil would quickly solidify.

"It's a very convenient thing for them to say it's going to be solid, but that's not what the facts show," said Deeda Seed, the Center for Biological Diversity's senior Utah campaigner.

"It is going to remain liquid for some period of time, it's not clear when or if it even becomes fully solid again," she added. "It could very well be the case that this stuff is very liquid all the way through the Colorado River Corridor."



📍 *Mile 219: Byers Canyon*

'Scary stuff'

After passing through the town of Kremmling and tiny, unincorporated Parshall, eastbound trains enter Byers Canyon in the Hot Sulphur State Wildlife Area, described by conservationists with the Colorado Birding Trail as prime nesting habitat for Swainson's thrush, Wilson's warbler, and the red-naped sapsucker.

Though no official statistics are kept, railroad enthusiasts identify Byers Canyon as the site of one of the sharpest "mainline" railroad curves in the country.

Like most other high-country canyons, it's also been the site of multiple train wrecks, including a 22-car derailment in 1982 deemed to have been caused by excessive speeds of nearly 60 miles per hour. Klancke, who's lived in Grand County for 52 years, remembers the aftermath.

"I saw train cars down a 200-foot embankment into the river," he said. Two other train accidents have occurred in Byers Canyon since then, including a four-car derailment in 2005 caused by rockfall on the track.



Railroad tracks along the Colorado River in Byers Canyon on June 11, 2023. (Chase Woodruff/Colorado Newsline)

In addition to predicting a spill of up to 30,000 gallons once every five years, the STB's environmental impact statement evaluated other scenarios, including fires and explosions, that are less likely but still a potential risk.

"If the force of the accident were sufficient to ignite the crude oil, a fire could result that could remain confined to a single car or could surround other cars and cause them to rupture," regulators said. "A fire that surrounds other cars could, in turn, cause a larger fire."

Even if the waxy crude had solidified in transit, opponents note, a fire that ruptured one or more tank cars would heat it back up to a liquid state. If spilled and dispersed into the river, it would cool to a solid again — but the railway's backers and their environmentalist foes have stark disagreements over what the cleanup process would look like from there.

In an op-ed earlier this month in the Deseret News, Heaton and Mark Michel of Drexel Hamilton Infrastructure Partners, the project's private-equity developer, wrote flatly that waxy crude "does not present an environmental concern if there were a derailment." In interviews, Heaton has repeatedly likened a spill of waxy crude to a spill of candles.

"It is like if you dropped a box of birthday candles in the kitchen sink," he told Deseret News. "You just pick them up."

Ted Zukoski, an attorney with the Center for Biological Diversity, ridiculed that comparison.

"It's just like picking up candles, if candles had warning labels on them that say they may cause organ failure and cancer, like the hazardous materials sheets for the two types of waxy crude they have in the Basin do," Zukoski said. "It's scary stuff."



Left: Waxy crude oil spilled into Utah's Price River after a tanker truck crash in July 2018. Right: Waxy crude spilled into Provo Canyon in November 2015. (Utah Department of Environmental Quality, U.S. Environmental Protection Agency)

To date, reported spills of Utah's waxy crude have largely been limited to tanker-truck crashes that released relatively small amounts of oil. But even those incidents complicate railway proponents' characterization of the oil as easy to clean up.

In 2018, a truck hauling heated waxy crude from the Uinta Basin overturned on a bridge over the Price River near Carbonville, Utah, spilling roughly 4,000 gallons. Although fewer than 1,000 gallons were estimated to have spilled into the river itself, the crude oil "formed quarter-size to fist-sized waxy globules scattered along (a) three-mile stretch of river from the crash site," Utah's Department of Environmental Quality reported. A series of flash floods in the days after the crash knocked out containment booms and sent the oil even farther downstream, with "significant contamination" ending five miles from the crash, the DEQ said.

A train accident on the Colorado River could spill far more oil – a single rail tank car has a capacity of 30,000 gallons – into a river that runs much higher and faster. Data from the U.S. Geological Survey shows that flash flooding in the week after the 2018 truck crash pushed the Price River's flow to a high of 82.8 cubic feet per second. The median flow rate of the Colorado River near Gore Canyon is more than 20 times higher; at the east end of Glenwood Canyon, the median rate is nearly 75 times higher.

"Even if (the waxy crude) is some form of a solid, the river doesn't care," said Godes. "The river – it breaks granite boulders apart. It's going to be able to break this down, break it apart and threaten the water supply for 40 million Americans."



Anglers float down Glenwood Canyon near Grizzly Creek on April 7, 2023. (Chase Woodruff/Colorado Newsline)

Exactly what impacts a major spill of hydrocarbons could have on the Colorado River is a question of vital importance to many of the communities that rely on it – but it's another issue that the Surface Transportation Board's environmental impact statement didn't address at all.

In their downline analysis, STB regulators focused narrowly on the increased traffic and accident rates on the existing Union Pacific route. The majority of the potential environmental impacts their report examined – including water contamination, wildfire ignition, habitat degradation and much more – were only assessed along the 88 miles of new railroad proposed in Utah, excluding the hundreds of miles of existing track in Colorado that the vast majority of the oil-train traffic would travel.

That lack of analysis lies at the heart of the lawsuit that Eagle County filed against the STB last year, arguing that the board's approval of the railway in December 2021 violated federal laws like the National Environmental Policy Act.

"The Board arbitrarily omitted the Union Pacific Line from its analysis of the Railway's impacts to water resources, biological resources, historic and cultural resources, and land use and recreation," the county's attorneys wrote in a brief earlier this year. "It failed to provide any reasonable basis for analyzing the Railway's operations on the proposed line but not on the Union Pacific Line."

In their environmental review, STB regulators wrote dryly that oil-train accidents "could result in several different outcomes and associated consequences, depending on the force of the collision or

derailment, the location of the accident, and the number of train cars involved." Minor accidents, they said, would be much more likely than major catastrophes.

In the event of a disaster, however unlikely, the report offers little analysis of what might happen next – an omission that has left communities along the downline route scrambling to study past oil spills, assess the potential threat to water quality, develop emergency-response plans and seek assurances that cleanup and recovery costs would be covered. For towns and businesses that are dependent on healthy river ecosystems, such questions, though barely a footnote in the STB's analysis, could be existential.

"How can you calculate truly the potential damages that could occur if you have a multi-car derailment in Glenwood Canyon?" asked Godes. "That would not only possibly devastate Glenwood's economy for several years, and compromising drinking (water) and recreation facilities up and down the river – and that's just in the immediate area, let alone the downstream impact to Grand Junction, and the Ute Water (Conservancy) District, and Moab, and even farther down."

EXHIBIT 9

The Wayback Machine - https://web.archive.org/web/20190209131104/https://deq.utah.gov/communication/ne...

Price River Oil Spill

A tanker truck carrying crude oil on Highway 6 rolled over on the evening of July 12, 2018, and released approximately 750-1,000 gallons of crude oil into the Price River. The Department of Environmental Quality joined emergency personnel at the scene to contain the spill and protect water quality in the Price River.



Emergency crews set up absorbent booms to trap oil before it heads downstream.

Carbon County Emergency Management (CCEM) staff put absorbent booms and pads in place overnight to minimize the spread of crude oil and gasoline. CCEM also contacted the local irrigation company and asked it to divert all possible water to the upstream canals, which lowered the Price River and kept the oil from being flushed farther down the river.

Price River Spill Activities July 18, 2018, to July 20, 2018

Envirocare completed one pass of cleaning for the entire contaminated area down to the Carbon Avenue Bridge on July 18, 2018. Very little contamination was found on the lower stretch of the river. A visual inspection check at the Wellington boom made by Southeast Health Department staff found no crude oil contamination at or below the boom. Envirocare made a second "polishing" cleanup pass along the entire river corridor on July 19, 2018.

DEQ's Division of Drinking Water (DDW) received final lab confirmation on samples collected July 16, 17 and 18, 2018. None of the samples collected from the Green River Water Treatment Plant pre-treatment holding ponds, plant influent, or finished drinking water contained oil and grease or volatile organic compounds (VOCs). The drinking-water plant operator will collect a final confirmation sample on July 20, 2018.

The DEQ District Engineer will collect water samples on July 20, 2018, at six locations along the Price River, and DWQ staff will pick up and deliver the samples to the lab that evening. Sample results should be available early next week.

Price River Spill Activities July 17, 2018



Crews remove oil globules. Click for larger view.

A significant flash flood on the evening of July 16, 2018, breached the lower containment boom at the Pilling Trailer Court. Since the cleanup was not complete, some contamination spread downstream. Cleanup crews found sporadic crude down to the Carbon Avenue Bridge. While the amount was small, this section of the Price River parallels the Price River Recreation Trail. Based on the proximity of the contamination to the trail, cleanup was extended two miles to the Carbon Avenue Bridge. Since the waxy crude is primarily globules and small chunks, crews are picking these up by hand.

Cleanup today will focus on the 100 North Bridge to the Carbon Avenue Bridge in the morning and 100 north to the Pilling Trailer Court in the afternoon. Significant contamination remains on "The Island" below Gordon Creek, and crews will clean up that area later today. Most of the cleanup should be completed today with some "polishing work" tomorrow, July 19, 2018.

Staff from the Division of Drinking Water (DDW) were at the Green River City drinking water intake on July 16, 2018, to collect a comprehensive suite of samples from holding ponds and treatment plant effluent. DDW is not expecting detectable results, but sampling is the only way to know for sure. DDW hopes to have final results late Thursday, July 19, 2018.

Price River Spill Activities July 15, 2018-July 16, 2018

Samples collected on July 13, 2018, showed gasoline range organics (GRO) levels were generally below limits downstream from the spill location. Diesel range organics (DRO) levels were elevated about 1000 feet downstream, but this was not unexpected given the small amount of oil residue and large chunks of crude in the water during sampling. DRO levels dropped sharply thereafter, which shows the oil residue is being diluted as the river runs downstream. DEQ Division of Water Quality (DWQ) crews will collect follow-up samples on July 18 or 19, 2018.



Sampling the Price River following the spill. Click for larger view.

DEQ's Division of Drinking Water (DDW) conducted sampling on July 16, 2018, above the Green River drinking-water intake. The plant is located approximately 100 miles downstream from the spill location, and cleanup crews estimate that less than one barrel (42 gallons) of oil flowed downstream towards the Green River. DDW wants to ensure that water entering and exiting the plant meets applicable drinking-water standards. Sample results should be available by July 20, 2018.

Cleanup near the spill site is proceeding well. Contractors estimate that all but a half mile of the river corridor has been "rough-cleaned" with at least one cleaning pass. Cleanup crews will focus on the last half mile on July 17, 2018, and begin a "polishing run" for the entire area of the river contaminated by the spill. Work is expected to be completed by July 18, 2018.

Price River Spill Activities July 13, 2018-July 14, 2018

Debris began to clog the diversion diverting water upstream on the morning of July 13, 2018. A five-minute planned water surge to clear the debris, unfortunately, blew out the first containment berm, flushing the crude oil downstream. A new containment berm was hurriedly placed before the oil progressed too far downstream, but by then, three miles of the river were to some extent contaminated by the spill.



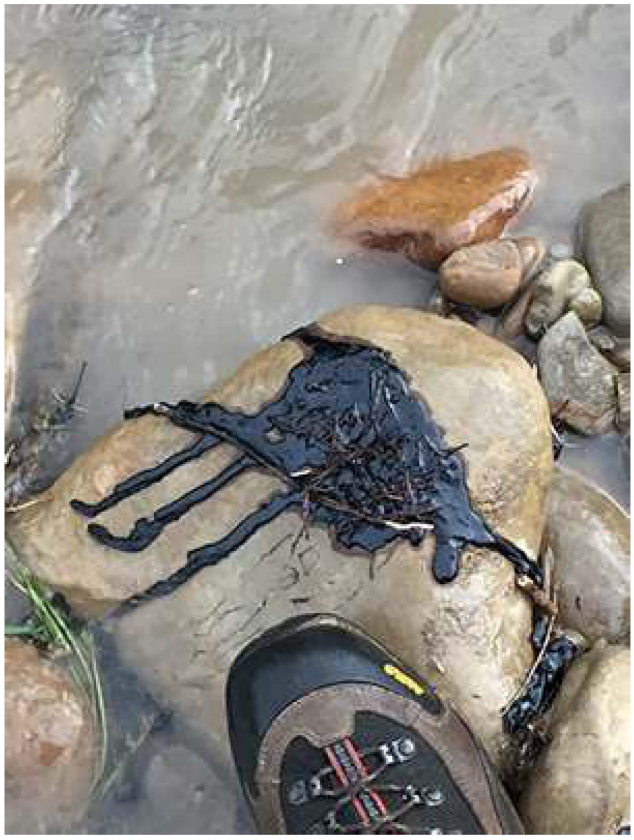
Booms contain oil and debris. Click for larger view.

The cleanup contractor, Envirocare, arrived early in the morning of July 13, 2018, and focused initially on collecting the crude oil on the bridge where the crash occurred. Thick oil also landed in trees, bushes, rocks, and embankments. The contractor worked with the irrigation company to "flush" the river by opening and closing the floodgates for a five-minute pulse, which pushed the thick oil toward the booms. A late afternoon rainstorm effectively "flushed" the system again, which pushed more crude oil down the river towards the containment boom.

DEQ Division of Water Quality (DWQ) monitoring staff and DEQ's Southeast Utah District Engineer were on hand to collect samples at four locations in the Price River. The release happened below the drinking water intakes for the Price River Water Improvement District (PRWID) and Price City, so local drinking water was not affected.

On July 14, another tanker accident occurred at the same location and spilled additional gasoline into the river. Absorbent booms and pads were used to soak up as much gasoline as possible. Responders estimate 10-15 gallons of gasoline ended up in the river.

The crude oil formed quarter-size to fist-sized waxy globules scattered along the three-mile stretch of river from the crash site all the way to the downstream containment boom. Since these globules float in the water, some of them were deposited along the banks when the flush water receded. During the afternoon, of July 14, 2018, cleanup concentrated on the removal of oil globules along two river miles. Crews collected forty-three bags of oil and debris during this "rough-cleaning," with each bag weighing approximately 15-20 pounds each.



Oil globules form on rocks. Click for larger view.

Heavy debris from a flash flood from the Gordon Creek drainage on the evening of July 14, 2018, took out the containment booms. An additional boom was put in place above Wellington to get ahead of the flood. However, before the booms were taken out by the flash flood, it's estimated that crews had cleaned up two-thirds of the oil spilled into the river.

DEQ will continue to update the public on the situation, including the results of water-quality tests from samples taken by DEQ in the Price River following the spill.

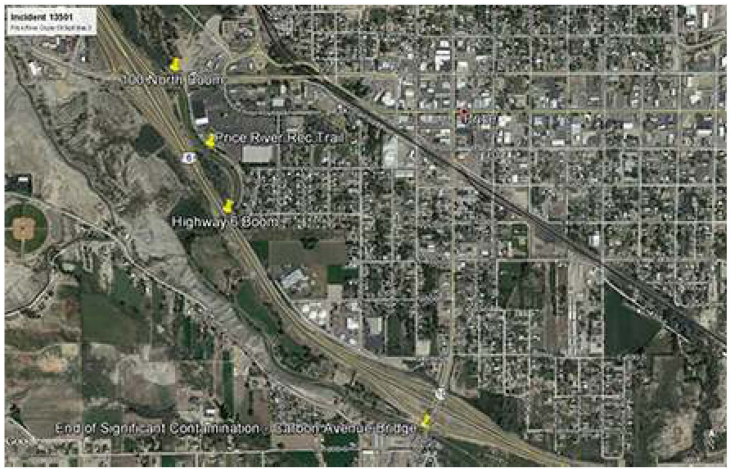
Price River Spill Incident Maps



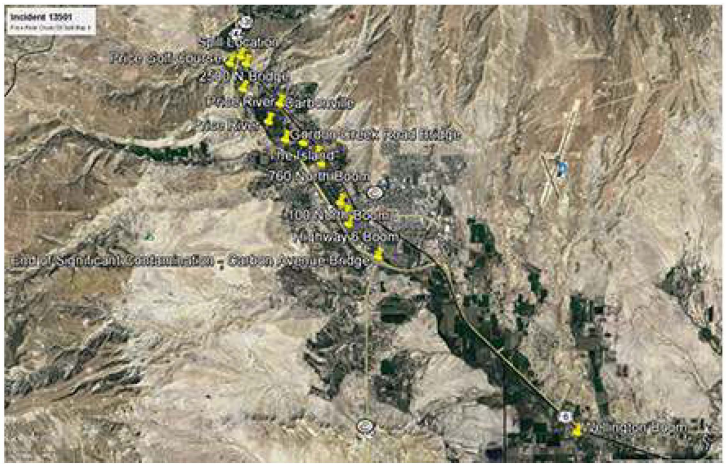
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⚠ Environmental Incidents (https://web.archive.org/web/20190209131104/https://deq.utah.gov/g

EXHIBIT 10

An official website of the United States government

United States Environmental Protection Agency

Search EPA.gov

Activities at this site have concluded, therefore updates are no longer available.



(region_list.aspx?region=8)



Site Contact:
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On-Scene Coordinator
(giggleman.craig@epa.gov) (mailto:giggleman.craig@epa.gov)

Site Location:
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Price, UT 84501
response.epa.gov/PriceRiverOilSpill
(https://response.epa.gov/PriceRiverOilSpill)
NRC#: 1218208

Resources

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At 22:00 hours on July 12, 2018, a tanker truck with a trailer pod carrying approximately 12,000 gallons of crude oil rolled over at mile marker 237 on SH 6 near the town of Price, in Carbon County, UT. The spill was originally reported as releasing approximately 1,000 gallons of crude, and 100 gallons of diesel into the Price River, and approximately 7,000 gallons of crude onto the banks. Based on new information, only one 4,000 gallon compartment on the front trailer was ruptured, spilling the entire contents. It is now estimated that 500-1,000 gallons reached the Price river, and 2,500 - 3,000 gallons was spilled onto the highway and median. The driver of the tractor trailer was injured during the accident.

Carbon County Emergency Management, EMS, Fire Department, and Highway Patrol were on scene. Booms were set at three locations downstream of the spill. Drinking water intake is upstream of the spill location. Approximately 98% of the water above the spill location is being routed around the spill and returned to the river below a second set of booms.

On July 13, 2018, 2:15 am EPA's oil spill contractor in Salt Lake City arrived on scene. The trucking company's environmental contractor arrived shortly after.

EPA Response OSC Giggleman and START contractor arrived on scene at approximately 8:00 am.

EXHIBIT 11

An official website of the United States government

EPA United States Environmental Protection Agency

MENU

Search EPA.gov

Activities at this site have concluded, therefore updates are no longer available.

Site Contact:
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OSC
(dhieux.joyel@epa.gov) (mailto:dhieux.joyel@epa.gov)

Site Location:
East of Provo, UT 84604
epaosc.org/provorivercrudeoil (https://www.epaosc.org/provorivercrudeoil)
NRC#: 1134430

At approximately 10:15 am Saturday, November 28, a crude oil truck overturned in Provo Canyon releasing its load of approximately 4,500 gallons. The truck was carrying a waxy crude from the Uinta Basin, and the oil solidified along the drainage and in the Provo River. An estimated 1000-1500 gallons of crude flowed into the Provo River. OSC Joyel Dhieux was dispatched to the scene at 11:30 a.m.MST.

The spill occurred approximately 3/4 - 1 mile upstream from the Olmstead Diversion Dam. The Diversion Dam provides drinking water supplies for Orem, Provo and Salt Lake City. The Central Utah Water District was promptly notified, and they closed their intake approximately 30 minutes before the first observation of oil. The water district is pulling water from an alternative source at this time. The water district also deployed boom, which appears to have successfully captured much of the oil. Thanks to the quick thinking and quick actions of the first responders and the Central Water District, the impacts from the spill have been substantially reduced.

Because of the cold weather conditions, the oil is congealing into soft solid chunks on the ground and in the Provo River behind the collection boom.


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For additional information, visit the **Pollution/Situation Report** (Pol/Sitreps) (sitrep_profile.aspx?site_id=11315) section.

Resources

Documents (doc_list.aspx?site_id=11315)

- RP NRC Report... (../sites/11315/files/NRC%20Report%201134433.pdf)
- Updated NRC Report... (../sites/11315/files/NRC%20Report%201134448.pdf)
- Initial NRC Report... (../sites/11315/files/NRC%20Report%201134430.pdf)
- All Documents (doc_list.aspx?site_id=11315)

Pol/SitReps (sitrep_list.aspx?site_id=11315)

POLREP - 3 (sitrep_profile.aspx?site_id=11315&counter=26663)

All Pol/SitReps (sitrep_list.aspx?site_id=11315)

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All Contacts (contact_list.aspx?site_id=11315)

EXHIBIT 12

U.S. ENVIRONMENTAL PROTECTION AGENCY
POLLUTION/SITUATION REPORT
Provo Canyon Crude Oil Spill - Removal Polrep
Final Removal Polrep

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region VIII

Subject: **POLREP #3**
Final PolRep
Provo Canyon Crude Oil Spill

East of Provo, UT
Latitude: 40.3564155 Longitude: -111.5770314

To:
From: Joyel Dhieux, OSC
Date: 2/19/2016
Reporting Period: December 4, 2015 - December 31, 2015

1. Introduction

1.1 Background

Site Number:	Z8FW	**Contract Number:**	
D.O. Number:		**Action Memo Date:**	
Response Authority:	OPA	**Response Type:**	Emergency
Response Lead:	EPA	**Incident Category:**	Removal Action
NPL Status:	Non NPL	**Operable Unit:**	
Mobilization Date:	11/28/2015	**Start Date:**	11/28/2015
Demob Date:	12/4/2015	**Completion Date:**	12/31/2015
CERCLIS ID:		**RCRIS ID:**	
ERNS No.:		**State Notification:**	
FPN#:	E16802	**Reimbursable Account #:**	

1.1.1 Incident Category

Oil Spill Emergency Response

1.1.2 Site Description

At approximately 10:15 am Saturday, November 28, 2015, a crude oil truck overturned in Provo Canyon releasing its load. The truck carried waxy crude from the Uinta Basin, and the oil solidified along the drainage and in the Provo River. An estimated 1,000 - 1,200 gallons of crude flowed into the Provo River.

The spill occurred approximately 3/4 - 1 mile upstream from the Olmstead Diversion Dam. The Diversion Dam provides drinking water supplies for Orem, Provo and Salt Lake City. The Central Utah Water District was promptly notified, and they closed their intake approximately 30 minutes before the first observation of oil. The water district withdrew water from an alternative source during the spill response. The water district also deployed boom which successfully captured much of the oil. Thanks to the quick thinking and quick actions of the first responders and the Central Water District, the impacts from the spill were substantially reduced.

1.1.2.1 Location

Near Mile Marker 13 on Highway 189 in Provo Canyon, Utah County, Utah

1.1.2.2 Description of Threat

Oil has entered waters of the United States.

1.1.3 Preliminary Removal Assessment/Removal Site Inspection Results

The tanker wreck caused the discharge of approximately 4,500 gallons of crude oil (the entirety of the load) to the road shoulder and stream bank of the Provo River. Savage Oil later revised the estimate to approximately 3,500 gallons spilled. It is estimated that 1,000-1,200 gallons of the Uinta crude oil entered the Provo River. Local officials with the Utah County Sheriff's Department and the North Fork Fire Protection District were quick to notify downstream water users and to bring in an environmental contractor (EnviroCare) to berm the crash site and to deploy boom in the Provo River. The oil was diverted away from the nearest water intake, the Olmstead Diversion Dam. This Diversion Dam was shut down and defensive measures were deployed. There were no reports of impacts from further downstream water users.

Due to the cold weather and water temperature, along with the waxy nature of the Uinta crude, the oil largely congealed into soft solid chunks. This greatly slowed the spread of the oil, but it did eliminate the use of vacuum trucks in oil recovery. Crews physically raked and lifted the congealed oil by hand from behind the collection booms.

2. Current Activities

2.1 Operations Section

2.1.1 Narrative

Local responders took quick steps to secure the scene and limit the spread of oil. The wrecked tanker was removed from the scene. On November 29, 2015 workers began removing contaminated soil from the crash scene, as well as chunks of oil from the Provo River at two collection points. All water intakes on the Provo River downstream of the spill were shut down, with alternative sources brought on-line.

Personnel from the UDEQ Water Program, along with OSC Dhieux, collected water samples from the Provo River on November 28 and 29, 2015. Central Utah Water District also collected water samples. The water sample results were low and/or non-detect for oil-related constituents.

The Provo River is valued as a blue ribbon fishery and is a highly used recreational area. In this section of the river, there are numerous families of beaver and muskrat. No impacts to wildlife or fish were observed. This is not surprising, given the waxy nature of the crude oil which has solidified in the cold water into flakes and chunks.

2.1.2 Enforcement Activities, Identity of Potentially Responsible Parties (PRPs)

Savage Services, Inc. of Midvale, Utah, is the Responsible Party. They have representatives on-scene.

2.2 Planning Section

2.2.1 Anticipated Activities

Oil collection continued through mid-December 2015, with the majority of the cleanup completed by December 7, 2015. The boom will remain in place through Spring 2016 to collect any oil that might have been stuck in the ice or vegetation. The amount of oil remaining in the river is expected to be minimal.

On December 3-4, 2015, Savage received approval to close one lane of the highway. The road closure allowed for safe removal of oil stained soil and vegetation adjacent to the road at the spill site. In addition, the storm water sewer was cleaned and washed by hand. Pacific West conducted the cleanup of this area of the spill.

In addition, Envirocare deployed several crews in boats along the river banks to collect oil. There were small areas along the banks with stranded flakes of oil. With several crews working, the majority of this oil was collected by December 7, 2015. Envirocare was also able to successfully collect oil that had been stranded in ice during a brief warm weather period on December 10-11, 2015.

2.2.2 Issues

The water intake was reopened beginning December 4, 2015, after the majority of the oil had been collected. There are no further issues remaining.

2.3 Logistics Section

Not Applicable

2.4 Finance Section

No information available at this time.

2.5 Other Command Staff

2.5.1 Safety Officer

NA

2.5.2 Liaison Officer

NA

2.5.3 Information Officer

NA

3. Participating Entities

3.1 Unified Command

UDEQ, EPA and Savage were in Unified Command

3.2 Cooperating Agencies

Central Utah Water

U.S. Fish and Wildlife

4. Personnel On Site

All personnel have demobilized. Savage Oil will continue to periodically monitor the site through spring.

5. Definition of Terms

None.

6. Additional sources of information

6.1 Internet location of additional information/report

Please visit www.epaosc.org/provorivercrudeoil

6.2 Reporting Schedule

This is the Final PolRep; no additional reports are anticipated.

7. Situational Reference Materials

None

EXHIBIT 13

An official website of the United States government

United States Environmental Protection Agency

MENU

Search EPA.gov

Activities at this site have concluded, therefore updates are no longer available.

Site Contact:
Steven Merritt (mailto:merritt.steven@epa.gov)
On-Scene Coordinator
(merritt.steven@epa.gov) (mailto:merritt.steven@epa.gov)

Site Location:
400 S Center ST
Duchesne, UT 84021
response.epa.gov/DuchesneOilfieldDumping (https://response.epa.gov/DuchesneOilfieldDumping)
NRC#: 955263

Sometime during the evening of September 23rd or early morning of September 24th, an unknown party discharged up to 40 barrels of crude oil from a truck, likely with some amount of produced water. The dumping occurred at the Duchesne County Fairgrounds in Duchesne City, where there is direct vehicle access via a ramp down into the Strawberry River. It was reported to Duchesne County officials on the afternoon of Friday, Sept 24th, 2010. Duchesne County Fire and Rescue/HAZMAT was the first agency on-scene and ordered oil spill response contractors. Cleanup crews arrived on Saturday, September 25, 2010 and began deploying containment boom and cleaning up the crude oil along the banks of Strawberry River.

Visual evidence of the spill was limited to about four miles below the fairgrounds, beyond the confluence of the Duchesne and Strawberry Rivers. The dumped product appears to be a heavy, waxy crude, that was likely less viscous when originally dumped and it was likely discharged at an elevated temperature. Once in the cold waters of the river, this crude oil congealed into lumps and adhered to vegetation and substrates in the channel. It appeared that most if not all of the contamination was originally on the surface of the water, very little if any appeared to sink. The contamination has left oily residues along the riverbank at the original elevation of the river and crews are working to clean up this oiled vegetation and globules of crude. Priority of effort is to remove contamination downstream of the confluence and then work upstream toward the spill site.

The land ownership surrounding the suspected discharge point is mixed, with portions belonging to the municipality, private land owners, and the Ute Tribe. The Central Utah Water Conservancy District (CUWCD) decreased flow in the Strawberry River to 15 CFS on September 24, 2010 from an original flow of 135 CFS to facilitate cleanup efforts. Flow controls on the Duchesne River are also in effect to facilitate the removal of oil. These low flows are a minimum in-stream flow for habitat for fish and wildlife, including threatened and endangered species, but prohibit downstream irrigation users from watering agricultural crops and livestock.


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For additional information, visit the **Pollution/Situation Report** (Pol/Sitreps) (sitrep_profile.aspx?site_id=6383) section.

Resources

Documents (doc_list.aspx?site_id=6383)

- Summary presentation about the... (../sites/6383/files/Duchesne%20Incident%20Overview.ppt)
- Letter from Department of Natu... (../sites/6383/files/KentJonesLetter.PDF)
- UDEQ Analytical for 9/24/2010... (../sites/6383/files/Post-Spill%20Water%20Quality%20Sampling%20Results.pdf)
- All Documents (doc_list.aspx?site_id=6383)

Pol/SitReps (sitrep_list.aspx?site_id=6383)

- POLREP - 2 (sitrep_profile.aspx?site_id=6383&counter=13949)
- All Pol/SitReps (sitrep_list.aspx?site_id=6383)

Links (links_list.aspx?site_id=6383)

- Deseret News - Duchesne County... (http://www.deseretnews.com/article/700069888/Duchesne-County-offers-reward-in-river-contamination.ht)
- Salt Lake Tribune - Duchesne o... (http://www.sltrib.com/sltrib/home/50388399-76/oil-duchesne-county-spill.html.csp?page=1)
- Salt Lake Tribune - Strawberry... (http://www.sltrib.com/sltrib/home/50353292-76/duchesne-river-county-oil.html.csp)
- KSL - More Crews Sent to Duche... (http://www.ksl.com/?sid=12587074&nid=148)
- All Links (links_list.aspx?site_id=6383)

EXHIBIT 14

Duchesne Oilfield Dumping Incident

www.epaosc.org/duchesneoilfielddumping

Duchesne, UT
September 24 – October 6, 2010
NRC Report 955263
FPN E10814

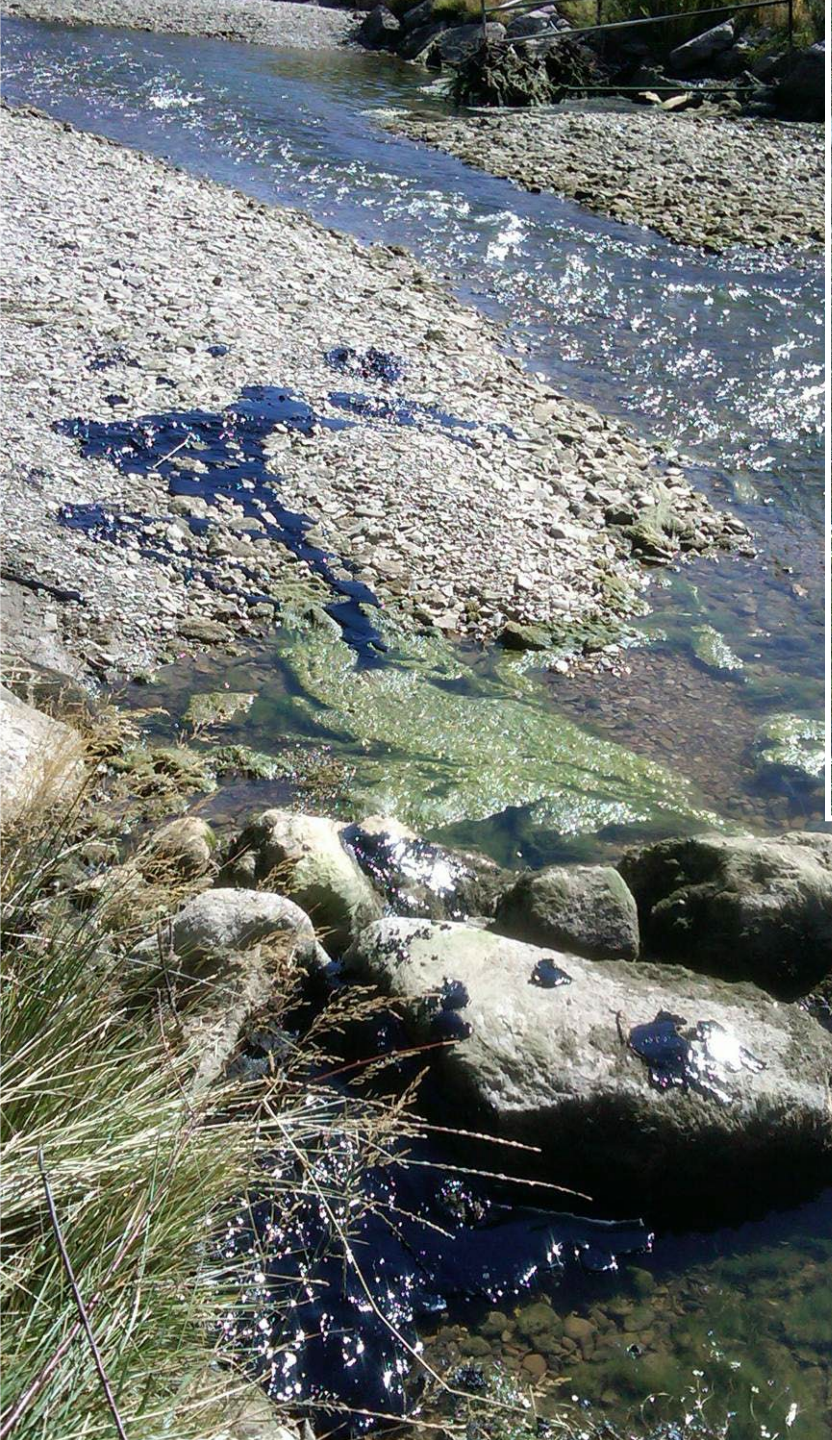
Key Response Issues

- Notification procedures and use of the NRC
- Knowledge and use of the Green River sACP
- Changing Oil Spill Response Organization (OSRO) tactics and priorities to fit response
- Pollution Reimbursement Funding Authorization (PRFA) to “save” Duchesne County complicated
- Balancing needs of the response with the “rights” of water users downstream
- Protecting T&E species and maintaining flows


Starvation Reservoir
To Upper Stillwater Reservoir (35 Miles)
To Green River (44 Miles)
Impacted Areas:
Strawberry ~ 1 mile
Duchesne ~ 3 miles
Duchesne River
25 CFS
Strawberry River
135 CFS
Duchesne
W Main St
E Main St
City Canal
Rocky Point Canal
Hillside Ave
W Stake Center Dr
N Center St
State Rd 399
River Rd
46220W
21000 W
9000S
5600'
311
40
87
191

Spill Discovery

- Discovered by local resident on recreation path
- Nearby water filling station for oil production
- Duchesne County (DC) FD and Emergency Management notified on 9/24/2010 at 1:30 PM
- DC Emergency Manager (EM) notified UDEQ and was given a list of OSROs to contact for support
- DC EM ordered OSRO to mobilize and respond under verbal contract
- UDEQ, TriCounty Health Department, & Ute Tribe representatives on-scene to size-up incident
- DC Sheriff finds evidence of “midnight dumping” of “up to 80bbls of produced water and oil” at ramp

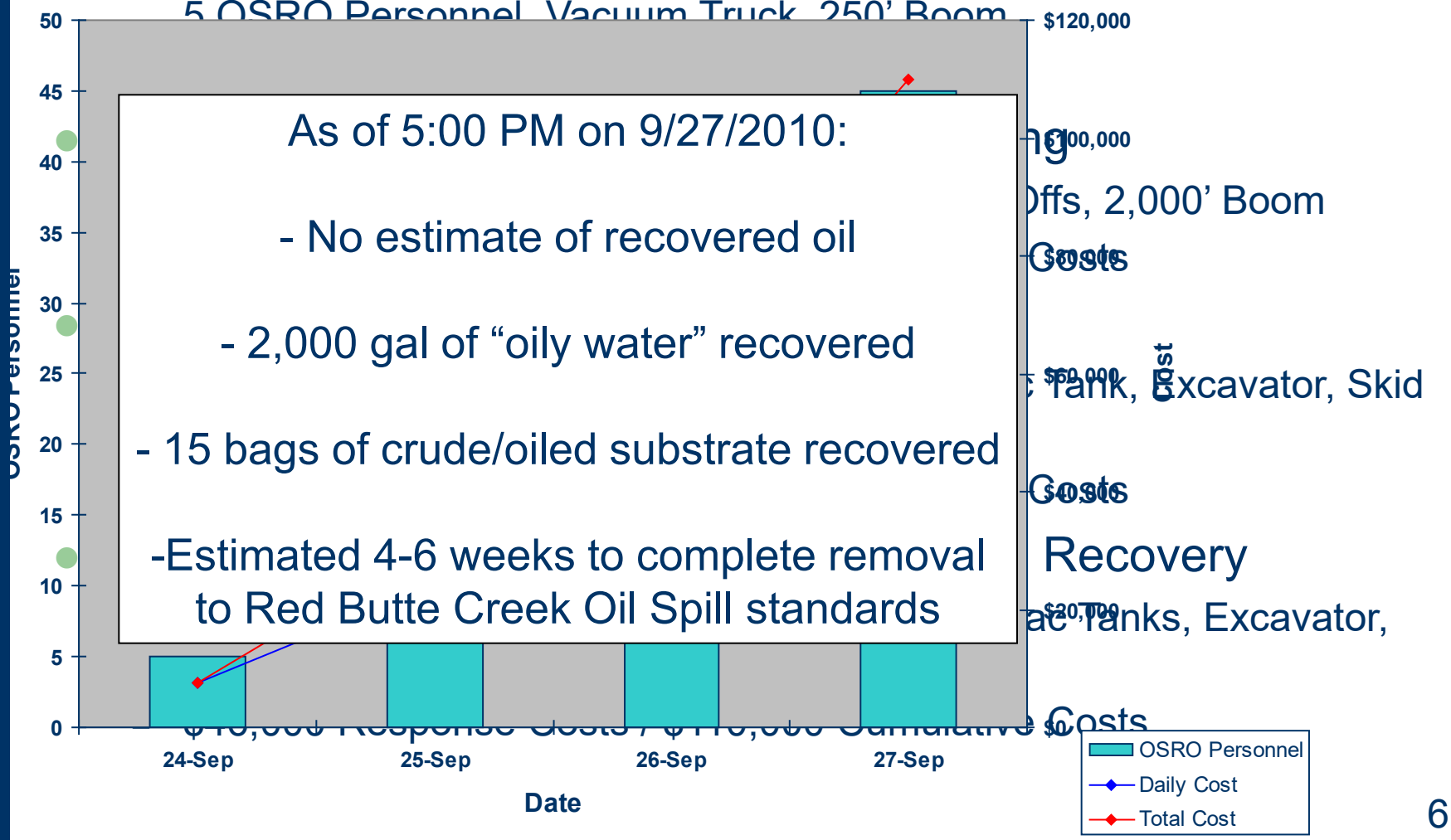






Initial Response & OSRO Escalation

- Friday, 9/24/10 – Flow Reduction, Booming
  - 5 OSRO Personnel, Vacuum Truck, 250' Boom











Notification to EPA

- UDEQ eMail to EPA Region 8 RRC
  - Saturday, 9/25/2010 @ 9:26 AM
  - “Debris, including petroleum products,”
  - “dumped [from truck] into [Strawberry River],”
  - “staying in clumps and not [mobile],”
  - “although booms placed to contain the spill.”
- TCHD call to National Response Center
  - Monday, 9/27/2010 @ 2:30 PM
  - “~20 bbls of crude oil dumped into Strawberry River”
  - “impacting 4 mi of Strawberry and Duchesne Rivers”
  - “OSRO on-scene, but EPA help/resources needed.”
  - EPA OSC Dispatched to Incident @ 3:05 PM

EPA Initial Response Actions

- Initial assessment of impacted river segments confirmed impacted areas and oil properties
- Convened UC meeting and worked to prioritize/right-size OSRO oil recovery efforts
- Consulted with DOI regarding T&E implications of reduced flows in Duchesne River
- Met with BIA and Ute Tribe about their concerns
- Considered mobilizing ERRS contractor to subcontract with OSROs
- Instead initiated discussions with the NPFC about issuing a PRFA with DC to fund response
- Stopped short of “ratification” for initial costs

Removal Effort

- Involved primarily physical/mechanical collection of clumps of oil and oiled substrate by crews
- Focused on working from impacted Duchesne River toward spill site to expedite restoring flows
- Extensive SCAT effort along impacted areas by UDEQ, DC, TCHD, EPA and Ute Tribe
- Worked closely with Central Utah Water Conservancy District to “flush” rivers
- Recovered ~10-12 bbls of crude oil during 10 days of response, which cost almost $500k
- DC still negotiating contract/invoice with OSRO












30 CFS




300 CFS

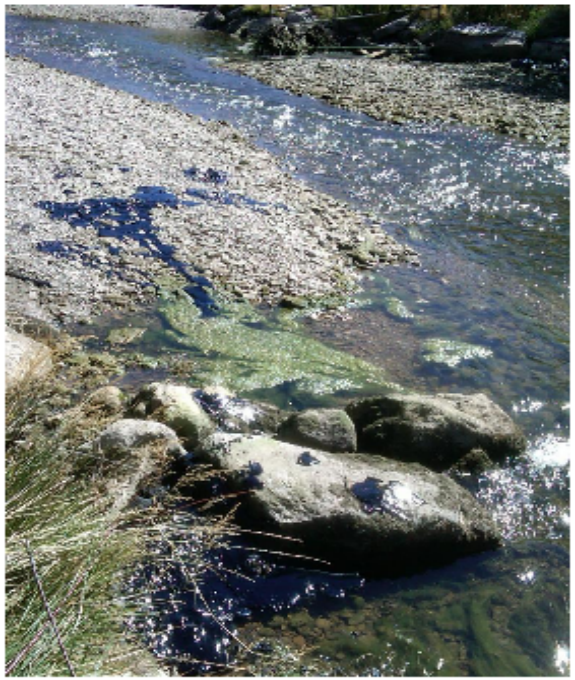
Lessons Learned & Recommendations

- Utilize NRC as “one call” phone number for Oil and HazMat spills; legally enforce compliance
- Cleaning up spills is our business; developing novel contracting mechanisms isn’t
- Discourage independent initiative and educate EMs about the inherent liability in spill response that is inconsistent with the NCP
- Conduct outreach in oil production areas, emphasizing costs/benefits of compliance
- Reinvigorate sACP updating and exercises in all nine Region 8 sACPs, beginning with Green River, Colorado River, and Missouri River



Duchesne Oilfield Dumping Incident

Duchesne, UT - EPA Region VIII
NRC#: 955263



Site Contact:
Steven Merritt
On-Scene Coordinator
merritt.steven@epa.gov

400 S Center ST
Duchesne, UT 84021
www.epaosc.org/DuchesneOilfieldDumping
Latitude: 40.1569600
Longitude: -110.4014500

KML | RSS | site map | area map | bookmark

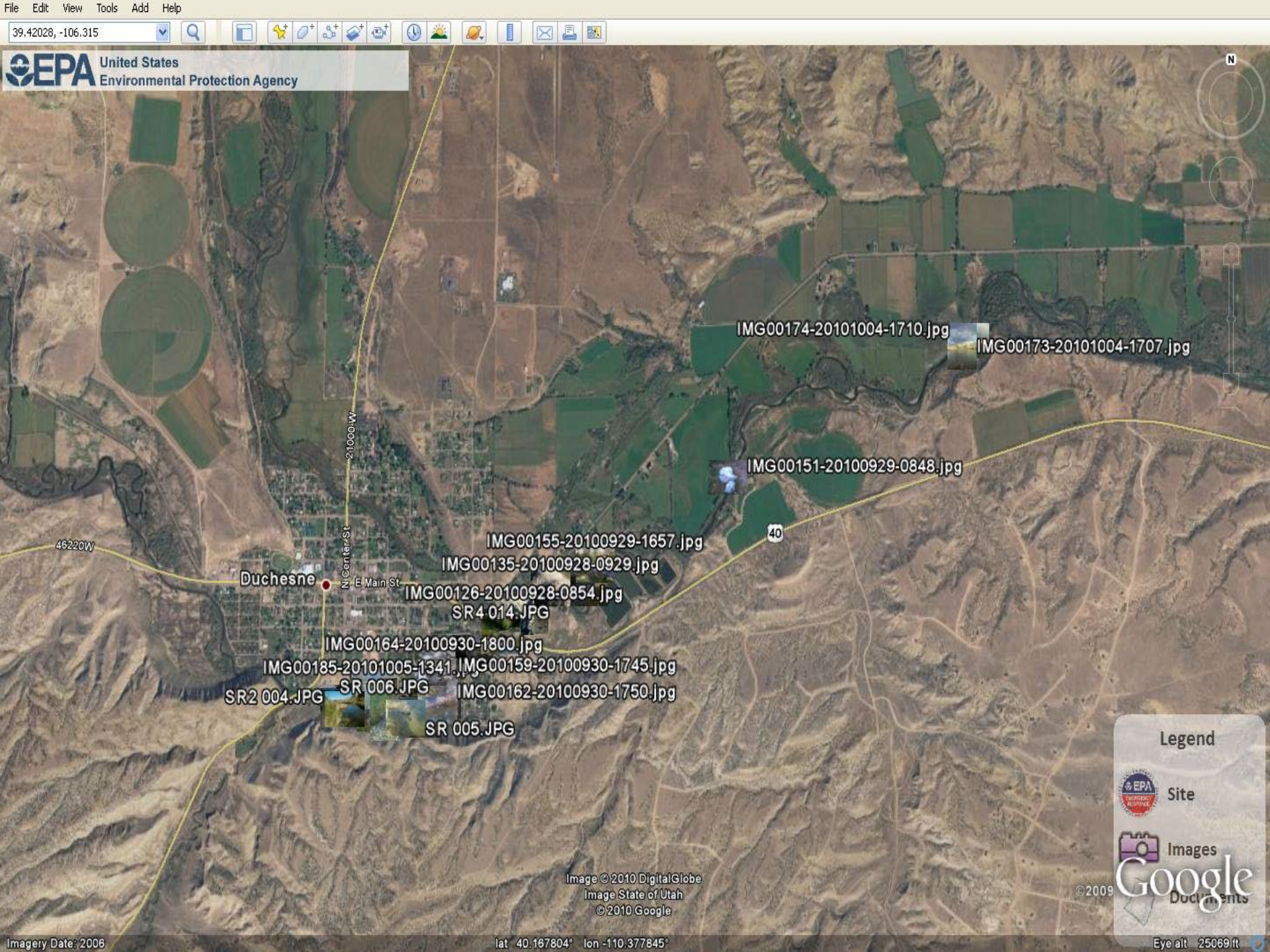
Google Earth File

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Bulletins
None for this site.
Images

List All...
Documents
Letter from Department of Natu...
UDEQ Analytical for 9/24/2010...
List All...
Pol/SitReps
POLREP - 1
List All...
Contacts
None for this site.
Links
Deseret News - Duchesne County...
Salt Lake Tribune - Duchesne o...
Salt Lake Tribune - Strawberry...
KSL - More Crews Sent to Duche...
List All...


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Duchesne
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Image State of Utah
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Google
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Site
Images
Documents
Imagery Date: 2006
lat 40.167804° lon -110.377845°
Eye alt 25069 ft

“Thank you for your support!”

Questions?
Criticism?
Outreach Ideas?
General Harassment?



Contact me…
Steven Merritt
On-Scene Coordinator
Merritt.Steven@epa.gov
303-312-6146

EXHIBIT 15

GARY R. HERBERT
Governor
GREG BELL
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
MICHAEL R. STYLER
Executive Director
Division of Water Rights
KENT L. JONES, P.E.
State Engineer/Division Director

September 29, 2010

To whom it may concern:

The Utah State Engineer who is charged under Utah law with the "general administrative supervision of the waters of the state and the measurement, appropriation, apportionment, and distribution of those waters" by this communication notifies parties which may be interfering with the lawful distribution of the waters of the state to entitled water right holders on the Strawberry and Duchesne Rivers that such action may constitute a taking under the United States and Utah Constitutions should the aggrieved parties be able to demonstrate that a loss has occurred. The State Engineer understands that the United States acting through the Environmental Protection Agency (EPA) is exercising management responsibility over the river to expedite the removal of hazardous waste, a noteworthy and important objective which is supported by the State of Utah and local water users. In that capacity the EPA is currently limiting the delivery of water in the river contrary to the wishes of those with rights to the use of the water. Under extraordinary circumstances like those, which have occurred with the release of this waste into the Strawberry River, the State Engineer recognizes restraint and cooperation from all parties will produce the most reasonable outcome and is hopeful the situation can be expeditiously resolved. It is hoped cooperation among the parties may continue until the emergency need is abated but I feel compelled to bring to the attention of all participating in the cleanup effort that there are rights to the use of water which must be considered as part of this effort.

Thank you for your efforts to maintain the quality of our precious public waters. If you wish to discuss this issue further please feel free to contact me at (801) 538-7371.

Sincerely,

Kent L. Jones, P.E.
State Engineer

KLJ/mtb

1594 West North Temple, Suite 220, PO Box 146300, Salt Lake City, UT 84114-6300
telephone (801) 538-7240 • facsimile (801) 538-7467 • TTY (801) 538-7458 • *www.waterrights.utah.gov*

EXHIBIT 16

January 24, 2022

Re: Concern Over Right-of-Way Permitting for Uinta Basin Railway

Northwest Colorado Council of Governments
WATER QUALITY / QUANTITY COMMITTEE
P.O. Box 2308
Silverthorne, CO 80498
970-596-5039
qqwater@nwccog.org

Dear Senator Bennet,

The Northwest Colorado Council of Governments Water Quality/ Quantity Committee ("QQ"), which comprises 40 local governments in the headwaters of the Colorado, Yampa, and Gunnison River Basins, would like to voice our deep concern for the proposed Forest Service Right-of-Way to allow the transportation of crude oil up the Colorado River to its headwaters via the Uintah Basin Railway.

We urge you to work with the Administration to halt the issuance of a right-of-way permit through the Ashley National Forest's Roadless Area because of the project's potential significant water quality impacts and carbon emissions.

The QQ region would see up to 350,000 barrels of oil on ten two-mile-long trains per day on the Union Pacific mainline, which runs along the Colorado River to its headwaters and then through the Moffat Tunnel, which is already nearing capacity. The significant increase in railroad traffic creates air quality and noise impacts through the Colorado River recreation corridor, renowned for rafting and fishing and thus an important economic driver for our region. The high volume of crude oil transported along the Colorado River, especially through Glenwood Canyon already struggling to recover from 2020 wildfires, makes a spill more likely and more catastrophic. A spill on the railway could affect drinking and irrigation water supplies for many miles along with the environmental harm. Union Pacific already has a history of releasing damaging sludge from the Moffat Tunnel into the Fraser River.

The local water quality impacts compound larger concerns for permitting a project that would generate 53 million tons of carbon emissions annually, posing a serious threat to clean air in the QQ region and in direct opposition to President Biden's recent actions on climate change, including Executive Orders 13990 and 14008 and would limit our progress as a state and a nation towards reducing greenhouse gas emissions.

QQ urges your office to take further action to prevent the Uinta Basin Railway from being approved. For questions or concerns, please contact Torie Jarvis, NWCCOG/QQ Director and Staff Attorney (970-596-5039; tjarvis@nwccog.org).

Sincerely,

Kathy Chandler-Henry
Chair, NWCCOG/QQ and Eagle County Commissioner
Kathy.chandlerhenry@eaglecounty.us

City of Glenwood Springs
101 West 8th Street
Glenwood Springs, CO 81601

The Honorable John Hickenlooper
B85 Russell Senate Office Building
Washington DC 20510

January 25, 2022

Re: Uinta Basin Railway Proposal Which Threatens Glenwood Springs and the Colorado River

Dear Senator Hickenlooper:

We write to ask for your assistance in helping to stop the proposed Uinta Basin Railway through the Ashley National Forest. If built, this Utah railway will send as many as ten, 2-mile-long heated oil tanker trains per day along the Colorado River through Glenwood Canyon/I70 corridor, Glenwood Springs, and other Colorado communities as they head toward refineries along the Gulf Coast. The potential for disaster from derailment, fire and spills, at a time when our state is suffering from the devastating consequences of extreme drought and wildfire is a risk Colorado cannot take.

We request that you ask the Forest Service to reject this right-of-way, as the trains from this railway would create new unacceptable risks to the health and safety of our community as well as others along the rail corridor.

Data on rail accidents show that because oil tanker unit trains are longer and heavier than other types of trains, they are harder to control and more likely to cause track failure. Spills from the type of crude oil proposed to be transported are hard to clean up in water because the oil remains as individual droplets. The threat to the health and integrity of the River and its precious water far outweigh the benefits of the proposed project.

The 2020 Grizzly Creek Fire in Glenwood Canyon and the resulting historic mud/debris flows of 2021 closed I-70 for several weeks and is still impacting transport. Cleanup is ongoing in the canyon to protect the integrity of I-70, the Colorado River and the UP Rail line during Spring runoff and future anticipated debris flows in the fire burn-scar area. The risk of mud/debris flows will exist in the burn area surrounding Glenwood Canyon for a decade to come – the risk of introducing heated oil trains to such a sensitive area is simply too great.

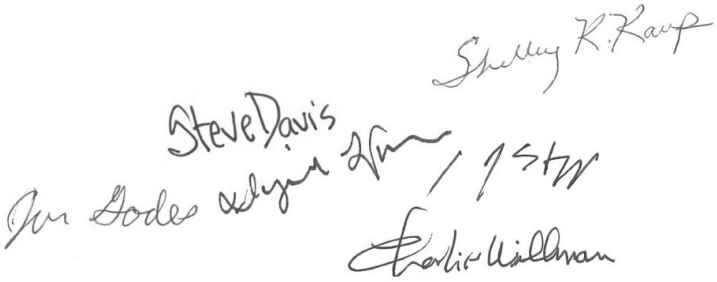
Alarmingly, the proponents of the railway have not analyzed the risk in their environmental impact statement, nor have they detailed any plan for dealing with the fire risk. Yet historical data shows that once a fire starts on a High Hazard Flammable Train – none have been controlled by using offensive strategies.

Finally, the railway's purpose is to quadruple fossil fuel extraction in Utah's Uinta Basin to up to 350,000 barrels per day. This at a time when our state is feeling the direct impact of the climate emergency. Enabling the Uinta Basin Railway would make that emergency worse, while directly endangering our community. Use of infrastructure funding to construct a railway for the purpose of expanding the extraction of carbon burning fossil fuel is problematic given the State and Federal Governments commitment to fighting Climate change.

We respectfully request that you use all means at your disposal to protect the public interest and urge the Secretary of the Agriculture to reject the proposed right-of-way for the Uinta Basin Railway through the Ashley National Forest.

We look forward to hearing from you. We understand that the Forest Service may make a final decision as soon as February 3, 2022.

Sincerely,



Jonathan Godes, Mayor

Charlie Willman, Mayor pro tem

Shelley Kaup, Councilor

Paula Stepp, Councilor

Steve Davis, Councilor

Ingrid Wussow, Councilor

City of Glenwood Springs, CO

CC4CA
Colorado Communities *for* Climate Action

February 11, 2022

The Honorable Senator Michael Bennet
261 Russell Senate Building
Washington, DC 20510

The Honorable Senator John Hickenlooper
Russell Senate Office Building
Suite SR-374
Washington, DC 20510

Re: Proposed Uinta Basin Railway

Dear Senators Bennet and Hickenlooper:

On behalf of our 40 town, city, and county member governments across Colorado, representing nearly one-quarter of Colorado's population, I am writing to express our concern about the proposed Uinta Basin Railway.

First and foremost, this railway will enable an enormous increase in the volume of fossil fuels extracted from the Uinta Basin. Given the impacts our communities are already suffering from climate change, any proposal that would dramatically increase GHG emissions should be viewed with considerable skepticism and caution.

Beyond the carbon pollution enabled by this proposal, every community along the corridor will be forced to face the risks of derailments, spills, and fires associated with the railway traffic. The consequences of any of these disasters would be severe. These communities are still working to recover from the disasters of the past two years, including catastrophic fire and the subsequent, and also disastrous, mudslides that paralyzed the state's single most important east-west transportation corridor. Climate change will continue to result in more extreme weather events and climate changed-fueled natural disasters, a reality that every community in Colorado will have to grapple with. These communities should not also have to face the risks tied to an unnecessary project that will contribute further to the climate process.

We ask and encourage you to take all possible steps to encourage the Forest Service to reject the right-of-way.

Respectfully,

Jacob Smith
Executive Director

Adams County · Aspen · Avon · Basalt · Boulder · Boulder County · Breckenridge · Broomfield
Carbondale · Clear Creek County · Crested Butte · Dillon · Durango · Eagle County · Edgewater · Erie · Fort Collins
Frisco · Gilpin County · Glenwood Springs · Golden · Lafayette · Longmont · Louisville · Lyons · Mountain Village
Nederland · Northglenn · Ouray County · Pitkin County · Ridgway · Salida · San Miguel County
Snowmass Village · Summit County · Superior · Telluride · Vail · Westminster · Wheat Ridge

GRAND COUNTY BOARD OF COMMISSIONERS

RICHARD D. CIMINO
District I, Fraser 80442
MERRIT S. LINKE
District II, Granby 80446
KRISTEN MANGUSO
District III, Kremmling 80459

E-Mail: grndcty1@co.grand.co.us
PHONE: 970/725-3100
Fax: 970/725-0565
EDWARD MOYER
County Manager
MAXINE LABARRE-KROSTUE
Acting County Attorney

March 8, 2022

The Honorable Michael Bennet
United States Senator for Colorado
261 Russell Senate Building
Washington, DC 20510

The Honorable Joe Neguse
United States Representative for Colorado
1419 Longworth House Office Building
Washington, DC 20515

The Honorable John Hickenlooper
United States Senator for Colorado
374 Russell Senate Building
Washington, DC 20510

Delivered via electronic mail:
john_whitney@bennet.senate.gov
sally_boccella@hickenlooper.senate.gov
sally.anderson@mail.house.gov

RE: Uinta Basin Railway Mitigation Request

Dear Senator Bennet, Senator Hickenlooper, and Representative Neguse,

The Grand County Board of County Commissioners recently discussed the Surface Transportation Board's approval of the Uinta Basin Railway proposal and its potential "downline" impacts throughout our county. Grand County could see up to 350,000 barrels of oil heading east on ten, two-mile-long trains per day on the Union Pacific mainline, which follows the Colorado and Fraser rivers prior to passing through the Moffat Tunnel.

While the Board does not oppose the Uinta Basin Railway project, we are very concerned with emergency services' capacity to contain a spill of crude or any of the related additional chemicals that this project may bring through Grand County. As you are aware, a derailment of this type of shipment in the headwaters of the Colorado River would be catastrophic. Containment and recovery would be extremely important and potentially very complicated, particularly if it occurred in one of our steeply sloping and rugged canyons. Because these trains employ special couplers that do not detach in order

to minimize puncturing of cars, a derailment could mean that whole trains or large sections of trains would need to be recovered. Grand County requests that comprehensive mitigation response plans be developed and equipment staged in Grand County should the project move forward as planned.

We understand that mitigation has already been proposed for the project, however Grand County urges your office to assist with seeking these additional protections against potential "downline" impacts to protect the Fraser and Colorado rivers, and all of the interests that are dependent on that clean and safe source of water, both here in Grand County and downstream.

Sincerely,

Kristen Manguso
Commissioner Chair

Richard Cimino
Commissioner

Merrit Linke
Commissioner

Cc:

Martin Oberman, Surface Transportation Board Chairman, rcpa@stb.gov
Matt Kireker, Central Mountains Regional Representative for Senator Bennet, matthew_kireker@bennet.senate.gov
Torie Jarvis, Northwest Colorado Council of Governments, tjarvis@nwccog.org
Doug Bellatty, East Grand Water Quality Board, dbellatty@townofgranby.com
Hattie Johnson, American Whitewater, hattie@americanwhitewater.org
Andy Mueller, Colorado River Water Conservation District, amueller@crwcd.org
Middle Park Water Conservancy District, middleparkwcd@gmail.com
Eagle County Board of County Commissioners, eagleadmin@eaglecounty.us

Gilpin County Colorado

Commissioners
Web Sill, District 1
Linda Isenhart, District 2
Sandy Hollingsworth, District 3

County Manager
Ray Rears

County Attorney
Bradford Benning

Located in the Historic
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Web Site
www.gilpincounty.org

Facebook
Gilpin County Colorado

July 19, 2022

305129

ENTERED
Office of Proceedings
August 12, 2022
Part of
Public Record
FD 36284

Brenda Mallory, Chair
Council on Environmental Quality
730 Jackson Place, NW
Washington, D.C. 20503

RE: Uinta Basin Railway Project – Letter of Opposition

Honorable Chair Mallory,

On behalf of Gilpin County and the Board of County Commissioners, we are formally expressing opposition to and requesting additional review of the Uinta Basic Railway Project, prior to approval.

As the Denver metropolitan headwater and first county located east of the continental divide, which includes a portion of the critical transportation and communications chokepoint, the Moffat Tunnel, we write to you to express our desire that the project's local and national safety concerns be addressed, along with the local and regional environmental impacts. These concerns should not be dismissed by the potential ease of transportation proposed as part of this project.

The introduction of up to 350,000 barrels of heated, waxy, crude oil a day transported through Gilpin County and Colorado along high alpine sensitive environmental areas, critical water supplies and through a nationally important transportation infrastructure has not been properly vetted. Specifically, if an oil spill were to occur and flow into the adjacent South Boulder Creek, it would have a catastrophic effect on the environment, both public and private, the state's water supplies and wildlife habitat. South Boulder Creek provides water for approximately 1.5 million residents downstream. Given the historic drought the western United States is and has been facing, any impact to this water system could have dire implications, far beyond the confines of Gilpin County.

We respectfully join with other Colorado counties in expressing opposition to the current planned route, with special consideration to downline impacts to the residents of Gilpin County and Colorado. This decision will have long-lasting, negative impacts on our communities, forests, waterways, and wildlife, and a more thorough environmental review, including local involvement is a necessity.

Sincerely,

Sandy Hollingsworth
Chair

Linda Isenhart
Commissioner

Cc: United States Senator Hickenlooper
United States Senator Bennet
United States Congressman Neguse
Colorado Senator Story
Colorado Representative Amabile
Eagle County Board of County Commissioners
Reading File

305130

ENTERED
Office of Proceedings
August 12, 2022
Part of
Public Record
FD 36284

Board of County Commissioners

August 11, 2022

Brenda Mallory, Chair
Council on Environmental Quality
730 Jackson Place, NW
Washington, D.C. 20503

Dear Chair Mallory:

We write to share our continuing concerns about the risks to Colorado and Boulder County from the pending Uinta Basin Railway Project. As the agency responsible for ensuring that environmental reviews for infrastructure projects are thorough, we request that you carefully review the analyses conducted by federal agencies thus far to determine whether the effects of this project on Colorado's communities, watersheds, and forests have been fully considered. Until such a coordinated and robust review is complete, we urge you not to allow this project to move forward.

Boulder County shares the concerns expressed by numerous Colorado local governments and stakeholder organizations. The risk associated with sending as many as ten, two-mile-long heated oil tanker trains per day along the Colorado River and ultimately through the Moffat Tunnel to Denver and beyond is nearly impossible to fathom. Every community along the rail corridor will be forced to face the risks of derailments, spills, and fires associated with this railway traffic. The consequences of any of these disasters would be severe and forced upon communities still working to recover from recent disasters, including catastrophic fire and the subsequent mudslides that paralyzed the state's single most important east-west transportation corridor, I-70.

Equally as risky is the enormous increase in the volume of fossil fuels extracted from the Uinta Basin that this railway will enable. Given the impacts our communities are already suffering from climate change, any proposal that would dramatically increase GHG emissions should be viewed with considerable skepticism and caution. Climate change will continue to result in more extreme weather events and climate changed-fueled natural disasters, a reality that every community in Colorado is already grappling with. Our communities should not also have to face the risks tied to an unnecessary project that will only further exacerbate climate change.

Matt Jones *County Commissioner* **Claire Levy** *County Commissioner* **Marta Loachamin** *County Commissioner*

Boulder County Courthouse • 1325 Pearl Street • Boulder, Colorado 80302 • Tel: 303.441.3500 • Fax: 303.441.4525
Mailing Address: P.O. Box 471 • Boulder, CO 80306 • www.BoulderCounty.org • commissioners@bouldercounty.org

We join with numerous Colorado counties and other key stakeholders, including Senator Bennet and Congressman Neguse, in respectfully expressing opposition to the Uinta Basin Railway Project, with special consideration to downline impacts to the residents of Boulder County and the South Boulder Creek watershed. If allowed to move forward, this project will have long-lasting, negative impacts on our communities, forests, waterways, and wildlife. A more thorough environmental review that includes local involvement is, at the very least, a necessity.

Sincerely,



Marta Loachamin
Chair
Boulder County Board of County Commissioners

cc: Sen. Michael Bennet
Sen. John Hickenlooper
Rep. Joe Neguse
Gov. Jared Polis

GRAND COUNTY BOARD OF COMMISSIONERS

RICHARD D. CIMINO
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MERRIT S. LINKE
District II, Granby 80446
RANDAL F. GEORGE
District III, Kremmling 80459

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EDWARD MOYER
County Manager
MAXINE LABARRE-KROSTUE
County Attorney

February 7, 2023

The Honorable Michael Bennet
United States Senator for Colorado
261 Russell Senate Building
Washington, DC 20510

The Honorable Joe Neguse
United States Representative for Colorado
1419 Longworth House Office Building
Washington, DC 20515

The Honorable John Hickenlooper
United States Senator for Colorado
374 Russell Senate Building
Washington, DC 20510

Delivered via electronic mail:
john_whitney@bennet.senate.gov
sally_boccella@hickenlooper.senate.gov
julie.sutor@mail.house.gov

RE: Uinta Basin Railway Mitigation Request #2

Dear Senator Bennet, Senator Hickenlooper, and Representative Neguse:

In a letter sent to you via electronic mail on March 8, 2022, the Grand County Board of County Commissioners did not take a formal position on the Uinta Basin Railway. However, we had considerable concerns regarding potential environmental impacts, and requested comprehensive mitigation response plans be developed and staged in Grand County should the project move forward as planned.

Following a recent presentation from Trout Unlimited Headwaters Chapter, as well as further discussion with county staff and other stakeholders on the potential environmental impacts to the Fraser River and Colorado River, we are now formally opposing this project until the following conditions are met:

1. A comprehensive mitigation response plan specific to Grand County is developed and approved by the Colorado Department of Public Health and Environment, Colorado Parks and Wildlife, and Grand County Government.

2. Containment and recovery will be extremely important and potentially very complicated, particularly if a derailment occurred in one of our steeply sloping and rugged canyons which are immediately adjacent to our rivers and streams. Therefore, prior to project commencement, the Seven County Infrastructure Coalition will incur the costs of placing an experienced contractor on retainer in the event of a waxy crude oil spill to promptly enact response plans. Response time will be critical to protect municipal water supply systems, our Gold Medal Trout fishery, and the livelihoods of our agricultural community and outdoor recreation economy. A derailment of this type of shipment is catastrophic.

3. Establish an escrow account for immediate mobilization and clean up costs, as well as issue a bond for long-term remediation. In 2010, the "Marshall" spill[1] on a tributary to the Kalamazoo River took 10 years to clean up and restore 35 miles of the river which were polluted by 843,000 gallons of crude oil. According to the Securities and Exchange Commission filing in 2014, the cleanup costs were well over $1.2 billion.

Grand County recognizes that oil needs to be transported before it is processed and distributed, however, we need assurances that all proper plans are in place to protect the headwaters of the Colorado River and not merely the state of Utah. In the last 50 years, there have been three derailments in our county, one of which resulted in a spill in Byers Canyon. This equates to an average of one derailment every 16 years. This project would bring an additional 3,650 two-mile long trains through Grand County each year, greatly increasing the odds of a catastrophic spill.

To summarize, Grand County is very concerned with the capacity and response times of the specialized emergency services capable of containing a crude oil spill (or any of the additional chemicals that this project may bring through our communities). Our watershed not only serves the citizens and visitors of Grand County, but the millions of people downstream and on the Front Range through transbasin diversions. In essence, should a spill occur in Grand County, it will have reverberating impacts across the entire state of Colorado.

Grand County respectfully requests you assist with ensuring these additional conditions are met to safeguard against potential environmental impacts to the Fraser and Colorado Rivers, and all of the interests that are dependent on that clean and safe source of water. Thank you for your continued support on matters within Grand County.

Sincerely,

Richard Cimino	Merrit Linke	Randal George
Commissioner Chair	Commissioner	Commissioner

[1] Garret Ellison, "New price tag for Kalamazoo River oil spill cleanup: Enbridge says $1.21 billion", *M Live*, November 5, 2014, https://www.mlive.com/news/grand-rapids/2014/11/2010_oil_spill_cost_enbridge_1.html.

Cc:

Speaker Julie McCluskie, julie.mccluskie.house@coleg.gov
Senator Dylan Roberts, dylan.roberts.senate@coleg.gov
Matt Kireker, Regional Representative for Senator Bennet, matthew_kireker@bennet.senate.gov
Martin Oberman, Surface Transportation Board Chairman, rcpa@stb.gov
Tom Vilsack, United States Department of Agriculture, tom.vilsack@osec.usda.gov
Doug Vilsack, Bureau of Land Management, dvilsack@blm.gov
Darcy O'Connor, Environmental Protection Agency, oconnor.darcy@epa.gov
KC Becker, Environmental Protection Agency, becker.kc@epa.gov
Jeff Rieker, Bureau of Reclamation, jrieker@usbr.gov
Patrick Fischer, Bureau of Reclamation, pfischer@usbr.gov
Dan Gibbs, Colorado Department of Natural Resources, dan.gibbs@state.co.us
Shoshana Lew, Colorado Department of Transportation, shoshana.lew@state.co.us
Jason Smith, Colorado Department of Transportation, jason.smith@state.co.us
Amber Blake, Colorado Department of Transportation, amber.blake@state.co.us
Trisha Oeth, Colorado Department of Public Health and Environment, trisha.oeth@state.co.us
Nicole Rowan, Colorado Department of Public Health and Environment, nicole.rowan@state.co.us
Monte Williams, United States Forest Service, mlwilliams01@fs.fed.us
Eric Freels, United States Forest Service, eric.k.freels@usda.gov
Robert Skorkowsky, United States Forest Service, robert.skorkowsky@usda.gov
Jon Ewert, Colorado Parks and Wildlife, jon.ewert@state.co.us
Jeromy Huntington, Colorado Parks and Wildlife, jeromy.huntington@state.co.us
Stephen Leonard, Bureau of Land Management, blm_co_kr_webmail@blm.gov
Andy Mueller, Colorado River Water Conservation District, amueller@crwcd.org
Eagle County Board of County Commissioners, eagleadmin@eaglecounty.us
Hattie Johnson, American Whitewater, hattie@americanwhitewater.org
Middle Park Water Conservancy District, middleparkwcd@gmail.com
Esther Vincent, Northern Water, evincent@northernwater.org
Rachel Badger, Denver Water, rachel.badger@denverwater.org
Mely Whiting, Trout Unlimited, mely.whiting@tu.org
Kirk Klancke, Trout Unlimited, kirkklancke@gmail.com
Rich Newton, Trout Unlimited, richardenewton@gmail.com
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Torie Jarvis, Northwest Colorado Council of Governments, tjarvis@nwccog.org
Claire Carroll, Northwest Colorado Council of Governments, ccaroll@nwccog.org
Doug Bellatty, East Grand Water Quality Board, dbellatty@townofgranby.com

Northwest Colorado Council of Governments
WATER QUALITY / QUANTITY COMMITTEE
P.O. Box 2308
Silverthorne, CO 80498
970-596-5039
qqwater@nwccog.org

March 17, 2023

The Honorable Michael Bennet
Cesar E. Chavez Memorial Building
1244 Speer Boulevard
Denver, CO 80204

The Honorable John Hickenlooper
Byron Rogers Federal Building
1961 Stout Street, Suite 12-300
Denver, CO 80294

The Honorable Joe Neguse
620 E Main Street
Frisco, CO 80443

Re: Request for Continued Opposition to Uinta Basin Railway

Dear Senator Bennet, Senator Hickenlooper, and Representative Neguse,

The Northwest Colorado Council of Governments Water Quality/Quantity Committee ("QQ"), which comprises 40 local governments in the headwaters of the Colorado, Yampa, and Gunnison River Basins. We shared our opposition for the Uinta Basin Railway with Senator Bennet in January of 2022. We appreciate your efforts to address and mitigate impacts to Colorado communities from the Railway and to stop the project if possible.

We recently learned that the project proponents are seeking to fund the railway through a tax-exempt Private Activity Bond (PAB) issued by the US Department of Transportation (DOT). This will effectively amount to tens of millions of dollars in public subsidies every year for a project that has significant environmental and health risks for Coloradans.

We respectfully request coordination of all your offices to oppose any use of PABs from the federal government for the Uinta Basin Railway, and that you continue to communicate your opposition both publicly and directly to the DOT and relevant agencies.

Heavy crude oils are highly toxic and very difficult to remove from a water source; contamination is severe and long-term. In addition, oil train derailments could cause devastating forest fires in Colorado's mountains. A federal agency review concluded the proposed new Railway would add up to 87 million gallons of waxy crude per week to the interstate rail system. Oil would be transported via as many as 180,000 loaded rail cars per year from the Uinta Basin to the mainline of the Union Pacific where it would travel east adjacent to the Colorado and Fraser Rivers. The Colorado River is the source of water for 40 million people and a river you're aware is in crisis. The Fraser River is an important and threatened tributary to the Colorado River which has already experienced degradation from decades of low flows due to diversions to cities on

the other side of the Continental Divide. The significant increase in railroad traffic raises concerns about both long-term and catastrophic water quality degradation in the Headwaters Region.

Long-term impacts from the increase in rail traffic may include, to name a few:

- Worsening of existing water quality challenges in the region, such as sedimentation and deposition of pollutants from the railcars into waterways.
- Further aquatic life impairment. Many waterways in the Headwaters struggle to sustain aquatic life and are fragile and sensitive to long-term increases in pollutants from increased rail car traffic.
- Union Pacific already has a history of releasing damaging sludge from the Moffat Tunnel into the Fraser River; the potential for additional releases would increase.
- The region's ability to meet water quality standards established by the EPA is unclear given these long-term impacts.

The increase in rail car traffic also increases the catastrophic potential for a train derailment and spill. As the recent, disastrous train derailment and chemical spill in East Palestine, Ohio shows, rail transportation of hazardous materials threatens communities, air, and water along the way. A catastrophic spill could have the following far-reaching impacts:

- Communities along the Colorado and Fraser Rivers could lose access to safe, clean drinking water and irrigation water supply.
- Environmental impacts would be widespread.
- The State's recreation and tourism economy would be adversely impacted because of the loss of fishing, rafting, and other water-based recreation income.
- Impacts in Glenwood Canyon could be particularly acute because the Canyon is already struggling to recover from damaging 2020 wildfires.
- Local investment in watershed restoration could be lost. Local governments and state and federal agencies are spending millions of dollars already to restore these watersheds. See, for example, Grand County Learning By Doing Cooperative Effort.

QQ asks that you object to PABs for a project that will cause harm to Coloradans. We request that you all communicate this both publicly and directly to Secretary Buttigieg and the Department of Transportation. For questions or concerns, please contact QQ Co-Director Claire Carroll at 719.740.0785 or ccarroll@nwccog.org.

Sincerely,



Kathy Chandler-Henry
QQ Chair and Eagle County Commissioner
Kathy.chandlerhenry@eaglecounty.us

CC:
John Whitney, Senator Bennet Regional Representative, john_whitney@bennet.senate.gov
Sarah McCarthy, Senator Hickenlooper Regional Representative, sarah_mccarthy@hickenlooper.senate.gov
Sarah Sutor, Representative Neguse Regional Representative, julie.sutor@mail.house.gov
David Oppenheim, Governor Polis Legislative Director, david.oppenheim@state.co.us
Tom Vilsack, United States Department of Agriculture, tom.vilsack@osec.usda.gov
Doug Vilsack, Bureau of Land Management, dvilsack@blm.gov
KC Becker, Environmental Protection Agency, becker.kc@epa.gov
Jeff Rieker, Bureau of Reclamation, jrieker@usbr.gov
Monte Williams, United States Forest Service, mlwilliams01@fs.fed.us
Martin Oberman, Surface Transportation Board Chairman, rcpa@stb.gov
Julie McCluskie, Colorado House Speaker, julie.mccluskie.house@coleg.gov
Dylan Roberts, Colorado State Senator, dylan.roberts.senate@coleg.gov
Perry Will, Colorado State Senator, perry.will.senate@coleg.gov
Marc Catlin, Colorado House Representative, marc.catlin.house@coleg.gov
Meghan Lukens, Colorado House Representative, meghan.lukens.house@coleg.gov
Elizabeth Velasco, Colorado House Representative, elizabeth.velasco.house@coleg.gov
Dan Gibbs, Colorado Department of Natural Resources, dan.gibbs@state.co.us
Shoshana Lew, Colorado Department of Transportation, shoshana.lew@state.co.us
Nicole Rowan, Water Quality Control Division Director at Colorado Department of Public Health and Environment, nicole.rowan@state.co.us
Jon Ewert, Colorado Parks and Wildlife, jon.ewert@state.co.us
Andy Mueller, Colorado River Water Conservation District General Manager, amueller@crwcd.org
Eagle County Board of County Commissioners, eagleadmin@eaglecounty.us
Jeff Shroll, Eagle County Manager, jeff.shroll@eaglecounty.us
Grand County Board of County Commissioners, grandcty1@co.grand.co.us
Edward Moyer, Grand County Manager, emoyer@co.grand.co.us
Jason Taussig, Denver Water Director of EMSS, Jason.taussig@denverwater.org
Sara Behunek, Denver Water Community & Government Relations Manager, sara.behunek@denverwater.org

General Assembly
State of Colorado
Denver

March 20, 2023

The Honorable Pete Buttigieg
US Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

The Honorable Tom Vilsack
U.S. Department of Agriculture
1400 Independence Ave SW
Washington, DC 2025

Dear Secretary Buttigieg and Secretary Vilsack:

As legislators who represent the areas of Western Colorado that would be impacted directly by the Uinta Basin Railway Project, we write to share our significant concerns and opposition to this project. We ask that you carefully consider this project's potential impact, including the devastating damage it could do to public health, our water resources, our environment, and our economy, when making the respective decisions charged to your departments. Further, we find the potential use of public taxpayer dollars through government approved tax-exempt private activity bonds (PABs) to finance this project to be highly objectionable, and we would strongly urge this approach to financing be rejected.

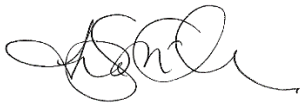
As you are aware, the Uinta Basin Railway Project would involve the shipment of heated waxy crude oil from Utah through Colorado, totaling as much as 350,000 barrels on ten, two-mile trains per day. This is immensely concerning given that the rail line runs right alongside the headwaters of the Colorado River and its tributaries, which provide water to over 40 million people in the Western United States, irrigate millions of acres of agricultural land, and drive our outdoor recreation and tourism industries, which are critical to our region's and state's economies.

In light of the recent train derailment in East Palestine, Ohio and other high-profile train accidents across the country over the years, a spill on this rail line is not only a possibility, it is likely. Such a spill would contaminate the local and regional water supply, as well as likely impact downstream consumers across the West. Given the heated nature of this transport and the widespread drought we are experiencing, this project also further increases the risk of wildfire ignition across the Western Slope. By threatening our water supply and increasing wildfire risk, this project would be truly catastrophic to our constituents, our communities, and our environment.

Our concerns with this project are grave and cannot be understated. We strongly urge you and your partners in the federal government to conduct a more thorough risk analysis in light of recent events and our pressing concerns regarding water supply and wildfire. While we understand and support the desire to increase domestic energy supply, the potential negative impacts of this project far outweigh any economic benefit. Imperiling the future of our environment and the natural resources we depend on and treasure is not a decision that should be taken lightly. Domestic energy development can and should happen through other means than this project.

A vast coalition of constituents that we represent on the Western Slope are opposed to this project, and we stand with them in this call to put a stop to this dangerous project that would jeopardize our long-term public peace, health, and safety.

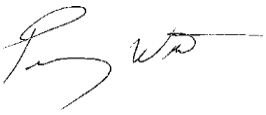
Sincerely,



Speaker of the House Julie McCluskie, HD-13



Senator Dylan Roberts, SD–8



Senator Perry Will, SD-5



Representative Meghan Lukens, HD-26



Representative Elizabeth Velasco, HD-57



Representative Barbara McLachlan, HD-59

CC:
The Honorable Joe Biden President of the United States
The Honorable Michael Bennet, U.S. Senator
The Honorable John Hickenlooper, U.S. Senator
The Honorable Jared Polis, Governor of Colorado
The Honorable Joe Neguse, U.S. Congressman
The Honorable Lauren Boebert, U.S. Congresswoman
The Honorable Brittany Petterson, U.S. Congresswoman

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CITY OF ASPEN

March 31, 2023

The Honorable Tom Vilsack
U.S. Department of Agriculture
1400 Independence Ave, S.W.
Washington, D.C. 20250

The Honorable Pete Buttigieg
U.S. Department of Transportation
1200 New Jersey Ave, S.E.
Washington, D.C. 20590

Re: Reject Funding Uinta Basin Railway Project with Tax-Exempt Bonds

Dear Secretary Vilsack and Secretary Buttigieg,

The City of Aspen, located in the headwaters of the Colorado River, wishes to express our deep concern and opposition of the Uinta Basin Railway Project. Our community, like our other headwaters neighbors, feels great responsibility and goes to great extent and expense to preserve, protect, and improve the quality of our air and water – for our residents and for the millions of visitors that journey to experience some of the most beautiful places in our country each year (1.5 million people visit Aspen and 10 million people visit the White River National Forest annually).

As the recent, disastrous train derailment and chemical spill in East Palestine, Ohio shows, rail transportation of hazardous materials poses a real threat to communities, air, and water along the way. The Uinta Basin Railway Project (Railway) proposes to add up to 87 million gallons of waxy crude oil per week, on as many as 180,000 loaded rail cars per year, to the interstate rail system that runs adjacent to I-70, splits the White River National Forest, and travels along the Colorado and Fraser Rivers. That's as many as five, two-mile long trains per day - 500 rail cars carrying 500 gallons of highly toxic, heavy crude oil, each. According to the Federal Railroad Administration, 89 train derailments occurred throughout Colorado between 2019 and 2023, 27% of which were the responsibility of Union Pacific. The potential for, and consequences of, a catastrophic accident are too high for our communities to bare. Drinking water contamination, loss of aquatic life, destruction to wildlife habitat, devastating forest fires, air pollution, and interstate closures, would cripple our environment, economy, and quality of life.

A catastrophic spill could have far-reaching impacts, beyond our community, as well. The project is proposed to follow along 100 miles of the Colorado River, which supplies drinking water and irrigation supply to 40 million people and is already in supply crisis. It increases the risk of wildfire in our drought-stricken watersheds. Closure of the I-70 corridor creates major supply chain issues that impacts everything from food security to construction capabilities. The State of Colorado could suffer billion-dollar losses in recreation and tourism economy from the loss of recreation and tourism assets as well as access to those assets.

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For these reasons, we that you stop the project if possible. We recently learned that the project proponents are seeking to fund the railway through a tax-exempt Private Activity Bond (PAB) issued by the US Department of Transportation (DOT). This will effectively amount to tens of millions of dollars in public subsidies every year for a project that has unacceptable environmental and health risks for Coloradans. We respectfully request that you reject the use of PABs from the federal government for the Uinta Basin Railway.

Sincerely,

DocuSigned by:
27248503ABD9483...

Torre

Mayor of Aspen

PHIL WEISER
Attorney General

NATALIE HANLON LEH
Chief Deputy Attorney General

ERIC R. OLSON
Solicitor General

ERIC T. MEYER
Chief Operating Officer

RALPH L. CARR
COLORADO JUDICIAL CENTER
1300 Broadway, 10th Floor
Denver, Colorado 80203
Phone (720) 508-6000

STATE OF COLORADO
DEPARTMENT OF LAW

Office of the Attorney General

April 21, 2023

The Honorable Pete Buttigieg
Secretary of Transportation
U.S. Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

RE: Uinta Basin Railway Application for Private Activity Bonds

Dear Secretary Buttigieg:

As the U.S. Department of Transportation ("USDOT" or "Department") weighs transportation projects worthy of federal investment, I urge the Department not to devote resources to the proposed Uinta Basin Railway. This rail project to transport waxy crude oil through Colorado poses significant risk to our State, our communities, and our natural resources. I ask that the Department reject any use of tax-exempt Private Activity Bonds—or any other source of federal funds—for this project.

The proposed route would construct an 88-mile rail line that would connect existing rail lines. This connection would transport up to 350,000 barrels of waxy crude oil on two mile-long trains through Colorado daily. The proposed route would run directly along sensitive and critical waterways including the Colorado River and its headwaters. Oil trains would also travel through other important ecosystems including the Fraser River and Arkansas River.[1] The plan has drawn resolute opposition from throughout Colorado,[2] particularly from communities that would be most impacted by the proposed rail line.[3]

The Colorado River serves as the most critical water source for Colorado homes and is core to our agricultural and outdoor recreation sectors. The proposal would steer the rail line project along the Colorado River headwaters—resulting in high numbers of train cars running daily alongside the river through mountains and narrow twisting canyons already prone to flooding, fire, and rockslides. The risk of rail car oil leaks, fire hazards, or potential

[1] Jason Blevins, *Railroad's Plan to Haul Waxy Crude Through Colorado's Mountains Needs $2 Billion in Government-approved Bonds*, COLO. SUN, Feb. 24, 2023.

[2] Letter from Sen. Michael Bennet, Sen. John Hickenlooper, and Cong. Joe Neguse to Secretary Pete Buttigieg, *available at https://www.bennet.senate.gov/public/_cache/files/9/3/9314b634-4a57-4ec2-baf6-1e48d9c6ed35/9FF00B2C65664A220F1299FA2EB447C6.2023.03.09-uintaletter-dot-final.pdf* (Mar. 9, 2023).

[3] Jason Blevins, *Eagle County Carries the Torch for Colorado in Last-ditch Attempt to Block Utah Waxy-crude Rail Cars Traversing Colorado River*, COLO. SUN, Sept. 22, 2022.

derailments poses an extreme risk to Colorado's most important water source and the surrounding environment. And a spill in Colorado could impact more than just our State—water from the Colorado River serves six other states, ten federally recognized tribes, and Mexico.

This risk is even more alarming given the recent catastrophic train derailment in East Palestine, Ohio. The major and lasting damage to the East Palestine community shows how an oil train accident can devastate a community and inflict permanent harm to residents.[4]

The Private Activity Bonds program has successfully invested billions to date in transportation projects throughout the Nation by leveraging private sector investment in public infrastructure projects. Under your leadership and past secretaries, this program serves as a model for how the public and private sectors can partner to deliver critical infrastructure projects—including high-occupancy vehicle lanes, managed lanes, light rail transit, and bridge and highway replacements. Projects funded through this program provide significant value to the traveling public. Yet, the Uinta Basin Railway offers no such mobility value to the public, but only to private sector interests. Federal Private Activity Bonds should benefit the public and prioritize moving people, not goods for a private industry actor. Furthermore, if approved, tax-exempt bonds devoted to the Uinta Basin Railway would have taxpayers subsidize a private venture, and one with significant community opposition. Such an approval would erode confidence in an important USDOT program that has aided so many critical projects and benefited the public.

I strongly encourage the USDOT to not invest Private Activity Bonds in such a risky and unsupported project. Should you or your staff have questions as you review this matter, please contact me or Kurtis Morrison, Deputy Attorney General, Department of Law at kurtis.morrison@coag.gov. Thank you for your consideration.

Sincerely,

Phil Weiser
Attorney General

cc: Mr. Carlos Monje, Under Secretary for Transportation Policy, USDOT
Mr. John Putnam, General Counsel, USDOT

[4] Tami Abdollah, *Trains Are Becoming Less Safe: Why the Ohio Derailment Disaster Could Happen More Often*, USA TODAY (updated Feb. 16, 2023); Timothy Cama, *Trump Officials Roll Back Obama Oil Train Safety Rule*, THE HILL (Sept. 24, 2018).

Chaffee County Board of Commissioners

P.O. Box 699/104 Crestone Ave.
Salida, CO 81201
719.539.2218/www.chaffeecounty.org

8 May 2023

The Honorable Tom Vilsack
U.S. Department of Agriculture
1400 Independence Ave, S.W.
Washington, D.C. 20250

The Honorable Pete Buttigieg
U.S. Department of Transportation
1200 New Jersey Ave, S.E.
Washington, D.C. 20590

The Honorable Michael S. Regan
U.S. Environmental Protection Agency
1200 Pennsylvania Ave, S.E.
Washington, D.C. 20590

Re: Opposition to Unita Basin Railway Project

Dear Secretary Vilsack, Secretary Buttigieg, and Administrator Regan,

Chaffee County Board of County Commissioners wishes to reiterate our strong opposition to the proposed activation and expansion of the Uinta Basin Railway (UBR) Project. Chaffee County leadership share the common opinion of others directly within the path and "downline" of the UBR corridor that the risks of transporting hundreds-of-thousands of barrels of toxic waxy crude oil through our mountain communities are simply too great for our residents and for the millions of visitors that journey to experience our region each year.

As has been seen with recent train derailments across the country, environmental and economic impacts that could result from derailment, wildfire ignition, and other elevated threats resulting from the Uinta Basin Railway Project could be catastrophic. According to the Federal Railroad Administration, 89 train derailments occurred throughout Colorado between 2019 and 2023, 27% of which were the responsibility of Union Pacific. The potential for, and consequences of, an accident are real and too great for our communities to bear; drinking water and soil contamination, degradation of air quality, loss of aquatic life, destruction to wildlife habitat, devastating forest fires, and interstate closures would cripple central Colorado's environment, economy, and quality of life.

Additionally, Chaffee County residents rely heavily on the I-70 corridor along which the UBR would run. UBR operations affecting I-70 have direct potential negative consequence for our community. Disruption or closure of the I-70 corridor cuts our residents off from critical services, creates major supply chain issues that impact everything from food security to construction capabilities, as well as negatively impacts our local tourism economy. Tourism is the largest job sector in Chaffee County and is crucial to our viability. We experienced comparable challenges during the 2020 Grizzly Creek Fire

Chaffee County Board of Commissioners

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when a substantial portion of I-70 traffic – coming from along the same route proposed for UBR – was rerouted through Chaffee County on Highways 50 and 285. This caused immense traffic delays, higher emergency-response costs, safety burdens, and tourism-related impacts to the county. We find it indefensible to willingly accept the increased and on-going risk of enduring these same types of issues due to UBR and its presence along the I-70 corridor.

Finally, we ask that UBR project proponents do not receive tax-exempt Private Activity Bonds (PABs) issued by the US Department of Transportation (DOT) to fund the UBR Project. This will effectively amount to tens of millions of dollars in public subsidies every year for a project that has unacceptable environmental and health risks for Coloradans.

We respectfully urge you to prevent the Unita Basin Railway Project from moving forward until it receives the adequate and objective review it requires to account for the full risks it introduces to Colorado's communities, water supplies, and environment, as well as its effects on climate change.

Sincerely,

The Chaffee County Board of Commissioners

Keith Baker, Chairman

Greg Felt, Commissioner

P.T. Wood, Commissioner

CC:
The Honorable Joe Biden President of the United States
The Honorable Michael Bennet, U.S. Senator
The Honorable John Hickenlooper, U.S. Senator
The Honorable Jared Polis, Governor of Colorado
The Honorable Joe Neguse, U.S. Congressman
The Honorable Lauren Boebert, U.S. Congresswoman
The Honorable Brittany Pettersen, U.S. Congresswoman

EXHIBIT 17

Saturday, January 10, 2026
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September 2025 Editor's Choice

Operators, Midstream Players Pursuing Upside Opportunities In Uinta, Denver-Julesburg Basins

By Danny Boyd

The term "unconventional gas" can be traced back to low-permeability formations on the Western Slope of the Rockies, and the concept of "tight oil" resource plays was proven up in the Bakken-Three Forks in North Dakota. True to its innovative history in developing both oil and gas resources, today operators continue to add new storylines as they pursue crude oil as well as natural gas-focused opportunities across the region, including in the Uinta and Denver-Julesburg basins.

The Uinta is a textbook example of the upside opportunities. The basin produces a waxy crude that is highly attractive to refiners transforming it into high-end lubricants, diesel and jet fuel. Twenty years ago, oil output averaged only about 20,000 barrels a day. However, with the adoption of horizontal drilling and hydraulic fracturing technologies, Uinta oil production has started trending toward historic highs. Some forecasts estimate that daily volumes could eclipse 250,000 barrels a day within the next few years, and with much of that oil shipped by rail to the Gulf Coast, rail transloading facilities are expanding in anticipation of winning more business.

Meantime, while rig counts in the D-J remain steady, upstream players are repositioning through acquisitions, divestments and partnerships as they look to develop both oil and liquids-rich gas targets in the Middle Wattenberg, Niobrara benches and Codell. The D-J midstream sector is also repositioning to better serve basin operators.

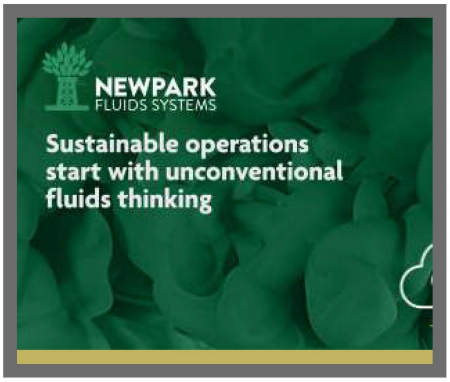
First Operated Pad

In late summer, "black wax" crude oil producer Berry Corp. was completing its first operated pad in the Uinta Basin, where it holds 100,000 net acres, mostly in Utah's Duchesne County. The pad includes four three-mile wells tapping the oil-rich Uteland Butte, reports Chief Executive Officer Fernando Araujo.

Early indicators were very favorable, pointing to cost savings and comparable output to non-operated pads and offset projects, he says. "Our horizontal delineation program is progressing in Utah, and we expect to unlock upside across our position."

According to Araujo, the Dallas-based company stimulated 255 stages with 600,000 pounds of sand and 13,000 barrels of water per stage. Sizeable cost savings of $500,000 per well came from the use of dual-fuel rigs and frac fleets and 50% utilization of produced water. Wells averaged $680/lateral foot.





"For a first-time operator drilling three-mile laterals, we are really encouraged with the achievement of being 20% below the cost compared to the six non-operated wells that we have and also compared to some of the other operators in the basin," Araujo remarks. "I think there is still room to improve on that."



Berry Corp. is completing its first operated pad in the Uinta Basin in Utah, where it holds 100,000 net acres. The pad includes four three-mile wells drilled to the oil-rich Uteland Butte formation. In all, Berry pumped 255 stages with 600,000 pounds of sand and 13,000 barrels of water per stage.

Berry acquired Uinta assets from Williams Companies in 2003 and did a bolt-on of Antelope Creek in 2022. The company holds most of its acreage with 1,200 vertical wells from an earlier development program that drilled in five zones. The assets give Berry extensive data for technical analysis of the basin's geology.

Neighbors to the north and east are tapping five reservoirs horizontally, including drilling into the Uteland Butte and Wasatch. A Berry non-operated well planned for the fourth quarter will test the Castle Peak, a combination of limestone and sandstone. The sandstone gets thicker as the play extends southward, giving Berry the potential for a thicker Castle Peak on its acreage, he explains.

A significant industry ramp-up in Uinta horizontal drilling over the last two years, coupled with $4.6 billion of industry transaction value in 2024, is driving Berry's efforts to develop its operated assets after experiencing strong results from non-operated pads, Araujo says.

Non-operated farm-ins have exceeded pre-drill estimates with estimated ultimate recoveries ranging from 55 to 60 barrels per lateral foot. The first non-operated horizontal Uteland Butte well performed at or above projected pre-drill rates, Araujo relates. Peak rates on each of two wells in a second farm-in averaged 1,950 boe/d.

With anticipated success ahead, Araujo says the door is wide open to Berry for the longer-term potential of cube development tapping multiple benches at the same time on the same pad.

Reinforcing operations are a Berry-owned gathering system and gas processing plant and compression system that can be used for gas lifting the wells, Araujo says. The company's crude production is transported by truck under short-term contracts to several Salt Lake City refineries and by rail to Gulf Coast plants.

Uinta Rail Terminal

Ample rail transloading capacity is crucial to accommodate anticipated growth in Uinta oil production, says Jim Finley, chief executive officer of Fort Worth-based Finley Resources, which owns a majority of Utah rail terminal operator Wildcat Midstream.

Expansions have boosted takeaway at the Wildcat terminal near Helper, Ut., converted to an oil facility after a 2018 acquisition of the Wildcat coal loading terminal from Los Angeles Power & Water, he recalls.

With the recent expansions, the Wildcat terminal and nearby company facilities can ship up to 100,000 bbl/d. Under a permit from the U.S. Bureau of Land Management, capacity of 40,000 bbl/d could be added on federal land as demand warrants, Finley says. The main rail competitor is Energy Transfer's Price River Terminal down the road at Wellington.



After converting a former coal loading facility near Helper, Ut., into the Wildcat oil rail terminal, Wildcat Midstream can ship up to 100,000 bbl/d from the terminal, with the capacity to expand by another 40,000 bbl/d. Wildcat Midstream ships mostly "yellow" crude, which makes up the bulk of the Uinta Basin's highly paraffinic, medium-to-high API gravity output.

"If there is 60,000 barrels a day of new Uinta production coming on over the next couple of years, we already have the capacity in our pocket, including our ability to expand," Finley remarks. "It is obviously a free market and everybody will compete for that additional business."

Finley Resources entered the basin in 2008 as a producer. In 2019, the company and partner CH4 Energy bought Crescent Point Energy's Uinta assets. The partners changed the name of Utah production operations to Uinta Wax, which today is managed by CH4, backed by NGP Energy Capital.

About 16,000 bbl/d of Uinta oil production is shipped to Wyoming for blending and transportation to Cushing, Ok., via the Pony Express Pipeline, Finley estimates. The rest is trucked to Salt Lake City refineries or shipped by rail to the Gulf Coast.

Wildcat Midstream ships mostly "yellow" crude, which makes up the bulk of Uinta oil production, Finley details. Uinta oil's medium-to-high API gravity and low levels of sulfur, acids, metals, and nitrogen make it attractive to refiners. Although not classified as heavy crude, its high paraffin content causes the oil to crystallize into wax at relatively high temperatures, prohibiting pipeline shipment without mixing, he explains.

Black crude solidifies into wax at 105 degrees Fahrenheit, and yellow crude produced from deeper depths crystalizes at 120 degrees, Finley says. At the lease, the crude is stored in tanks heated to 170 degrees. Wildcat contracts with eight trucking vendors that use insulated tank trailers to transport up to 130 loads a day from leases to its rail terminals.

Crude is offloaded into 1,450 Wildcat-owned, insulated railcars at about 150 degrees. The waxy crude solidifies during the five to six-day trip to the Gulf Coast, he explains. By pumping steam through coils on the rail cars, the oil is re-liquified at the refineries.

D-J Partnerships

Publicly held PEDEVCO Corp. operates approximately 19,500 acres in Colorado and Wyoming and is making major moves to boost D-J Basin development through partnerships with bigger private players, says President and Chief Executive Officer J. Douglas Schick. The Houston-headquartered company is focusing on work in Colorado, where larger partner companies with bigger staffs can better navigate the state's regulatory challenges and simultaneously develop multiple drilling spacing units.

"For us to bring out a rig and completion crew for one drilling spacing unit (DSU) a year is highly inefficient compared to partnering with someone else who is running a rig and completion crew full time, therefore, realizing significant cost savings and synergies. We prefer taking up to a 40-50% working interest and letting them do the work," Schick says.

By the end of the year, four new horizontals, including one U-shaped lateral, will be drilled and completed in the Niobrara B on the Roth DSU in Weld County under a joint development agreement with a large private equity-backed company.

In exchange for $1.7 million, PEDEVCO transferred operatorship and reduced its Roth working interest from 70% to 44%. The new operator can acquire up to 50% of PEDEVCO's holdings in the nearby Amber DSU, giving each company up to a 45% working interest. The partner has already increased the size of each DSU from 1,280 to 1,600 acres to accommodate longer laterals.



In Colorado, PEDEVCO Corp. is partnering with other operators to efficiently develop multiple drilling spacing units. Under a joint development agreement with a large private equity-backed company, PEDEVCO will drill and complete four horizontals, including one U-shaped lateral, in the Niobrara B on the Roth DSU in Weld County by the end of the year. In collaboration with another large private player, drilling is expected to get underway later this year as part of a five year agreement to drill at least five wells annually on a combined 10,750 net acres.

In collaboration with another large private player, drilling is expected to get underway later this year, Schick reports. The arrangement incorporates 10,750 net acres held by the two companies with 70% ownership for the private operator and 30% for PEDEVCO, he details. At least five wells will be drilled annually over five years, although up to 18 could be spudded yearly.

The players expect strong well results, he says. Recent offsets near joint positions and PEDEVCO's own developments include 30-day IPs ranging from 600 to 1,000 boe/d and cumulative production per well averages of 200,000 boe in the first year after completions using over 2,000 pounds of proppant in each foot of lateral.

PEDEVCO formed in February 2011 to acquire and develop D-J assets and eventually added Continental Resources' properties in the basin. After the 2014-15 downturn forced a drilling stoppage, a new management team led by Schick and a partner acquired a controlling interest in 2018.

However, stricter state regulation authorized by Colorado's SB 181 soon influenced the team to focus instead on developing a 14,000-acre San Andres position in the New Mexico Permian. Then came COVID-19.

With complications subsiding, in 2021 PEDEVCO began adding D-J acreage. Today, about 14,600 acres are in Colorado and the rest across the state line in Laramie County, Wy. The company began ramping drilling in 2022 and has continued to secure permits, according to Schick.

In addition to recently divesting of non-core, low-working interest wells, the company continues to aggressively look for leasing opportunities in the D-J, where permitted Colorado acreage can go for $6,000 an acre and non-permitted for $300-$1,000 per acre, he notes.

Midstream Expansion

Backed by a corporate strategy of building scale through strategic bolt-ons in key basins, Summit Midstream is expanding in the D-J to better service operators, says Daniel Seaver, vice president of commercial development for the Houston-based company.

With other operations in the Williston, Fort Worth, Piceance and Arkoma basins, Summit has completed three D-J acquisitions over the past three years with a focus on gathering and plants that process associated gas in oily areas. The latest this year was Moonrise Midstream and its operations in Weld County, following Summit's acquisitions of the midstream assets of Outrigger Energy and Sterling Energy in 2022.

Integration over the past two years has resulted in better field pressures and recoveries and more reliability, Seaver says. "We are definitely treating the D-J as a core asset. We like it, and we like that valuations have not gotten to the level of those for the Midland and Delaware basins or the Eagle Ford," he comments. "We can still remain very accretive to an investor base for a company our size. There is a handful of other opportunities that we really like, and hopefully we will see a couple of them come to market."



Earlier this year, Summit Midstream closed on an acquisition of Moonrise Midstream facilities in Weld County, Co. That deal followed Summit's 2022 acquisitions of midstream assets of Outrigger Midstream and Sterling Energy. Focusing on assets that gather and process associated gas in oily areas in the D-J Basin, the Moonrise acquisition adds 65 MMcf/d in processing capacity with the potential to expand to 100 MMcf/d.

The company transports 20,000 bbl/d of crude in the D-J and acquired a freshwater business through Sterling, but the transactions have transformed Summit into more of a gas gatherer and processor in the basin, Seaver adds.

In addition to gathering and compression assets, the Moonrise purchase from Fundare Resources Company Holdco came with 65 million cubic feet a day of processing capacity expandable to 100 MMcf/d with a modest capital investment, he remarks.

Seaver says the purchase adds redundancy and flow assurance and is supported by long-term, fee-based contracts. Throughput is backed by acreage dedications in oily areas from Fundare, Verdad, Bison IV and a large public company. Residue gas is transported to the Rockies Express Pipeline, liquids to Overland Pass Pipeline, and crude to Pony Express. This adds to the already existing robust downstream options, via Cheyenne Plains, CIG on residue gas and White Cliffs on NGL volumes.

Summit entered the D-J in 2013 with the acquisition of midstream player, Bear Tracker Energy. Assets included the Hereford gas plant located in Weld County near EOG Resources' Jake No. 2-01H, credited for reopening the Niobrara oil play.

According to Seaver, the company's gas processing is about 50% utilized right now but can be boosted quickly to about 300 MMcf/d with more development expected to soon follow behind the system as upstream companies launch expected multiyear development plans in 2026.

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Meet The Secretive 'Mastermind' Behind Utah's Oil Boom

Production in Utah's oil-rich Uinta Basin is at an all-time high. Texas oilman Jim Finley is credited with opening the floodgates.

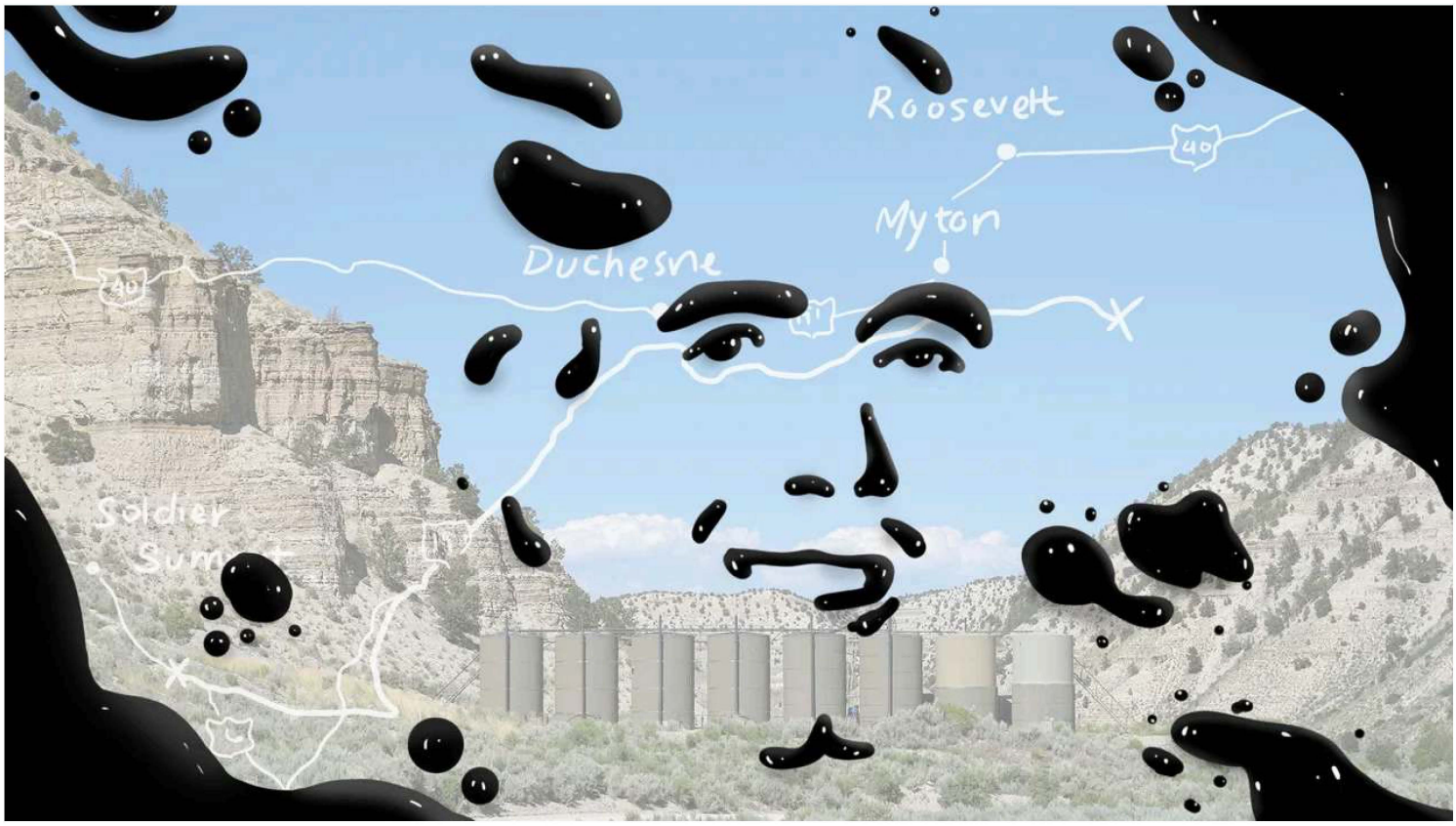
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Jan 31, 20[illegible], 0[illegible]

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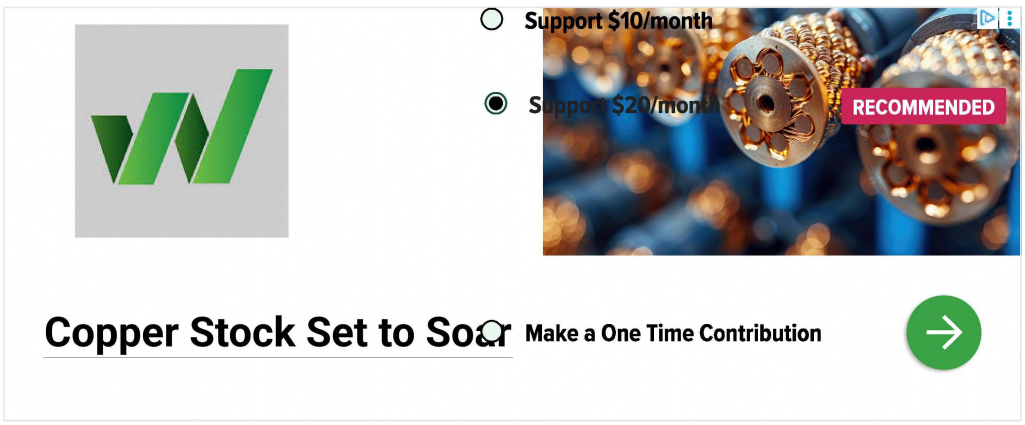


Crude oil production in the Uinta Basin has long been captive to the capacity of refineries in Salt Lake City. Texas oilman Jim Finley has championed shipping oil out of state, and basin production is now soaring. MADDIE ABUYUAN / HUFFPOST; RICK BOWMER / AP PHOTO

Jim Finley is a bit of a ghost. Outside of oil industry circles, few people have probably ever heard of the man. He rarely speaks in public.

One exception was in October 2021, when Finley, the CEO of Texas-based Finley Resources, presented to a coalition of seven oil-producing counties in eastern Utah. Following his speech, coalition board members and staff applauded Finley for his investments in Utah's oil-rich Uinta Basin, and thanked him for making time to speak. One person noted that he is a particularly difficult man to get hold of.

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"Sometimes nobody knows where I am," Finley said.

“On purpose,” someone else chimed in. Finley chuckled.

The Texas oilman has played a key role in spearheading the kind of oil boom that has long evaded the remote basin. In just over a decade, he’s become one of the top producers in the Uinta and is now playing an outsize role in shaping Utah’s energy future.

Finley has thrown his support behind a controversial rail line that would make it easier for him and the basin’s five other producers to export oil to out-of-state markets, while simultaneously boosting export capacity via trucking and existing rail. He has his fingers in every aspect of basin production, from drilling oil and mining sand for hydraulic fracturing to operating a transloading facility and a growing fleet of oil trains. Powerful political allies have helped him expand his empire, primarily by funneling public money toward infrastructure projects that benefit the oil sector.

Chris Kuveke, a researcher at BailoutWatch, a watchdog group that provided HuffPost with extensive research on Finley’s portfolio and operations, called Finley “the mastermind” of the basin’s current oil boom.

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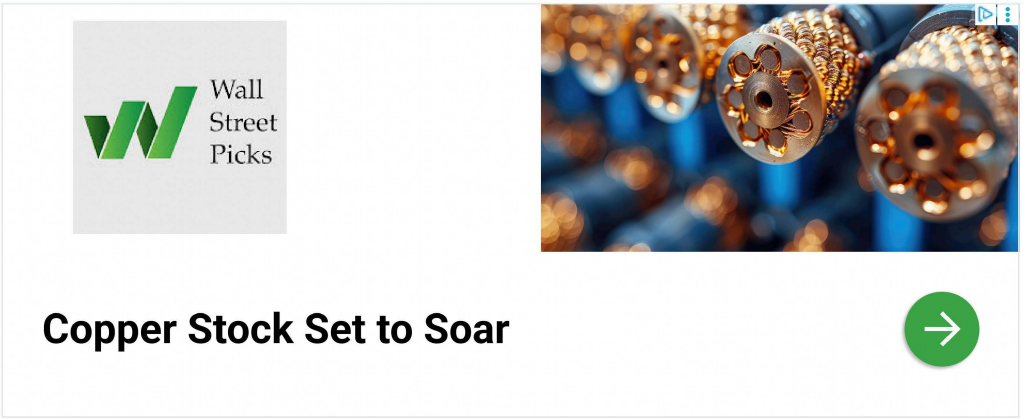
“He has a long history of using campaign finance and lobbying as influence to get his projects where he wants them to be,” Kuveke said. “He knows what he’s doing. He has a serious track record of influencing the industry that he wants to grow, being a linchpin. And that’s what he’s doing in the Uinta.”

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Finley and other producers’ long-term vision for the Uinta could lead to as much as 350,000 barrels of crude oil being railed from Utah to Gulf Coast refineries every day, roughly tripling current basin production and increasing U.S. annual petroleum emissions by 1%.

Oil and gas industry players and longtime observers, including two who requested anonymity to speak plainly about the Uinta’s trajectory, credited Finley for the basin’s recent growth.

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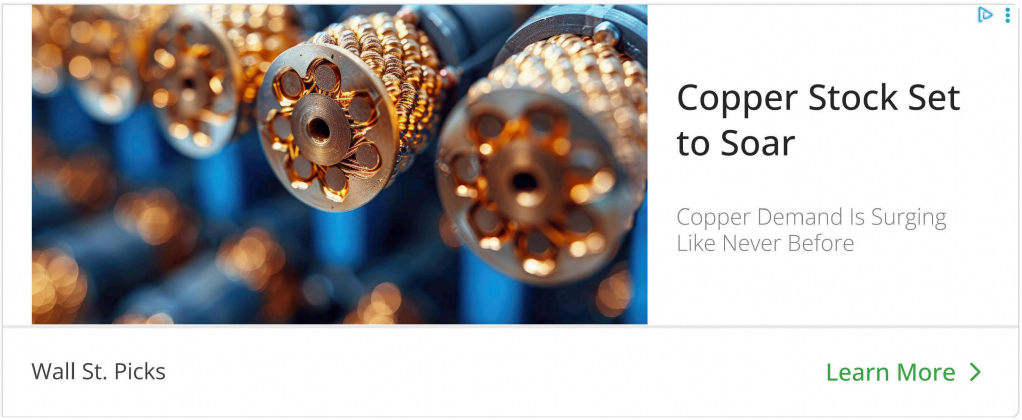


"He kind of broke the seal," a current industry official told HuffPost, adding that other basin producers have followed Finley's lead in shipping oil out of state.

A retired industry professional called Finley the "puppetmaster" of Utah energy policy, and admitted to having "a degree of rueful admiration" for how he's secured public funds for his ventures.

"It is a classic story of using 'other people's money' — in this case, that of Utah taxpayers — while leaving them stuck with the environmental and public health bill," the retired professional told HuffPost.

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Finley did not respond to HuffPost's multiple requests for comment. Nor did Brent Talbot, the president of Finley Resources, or other company representatives — continuing a pattern they've demonstrated with other news outlets. If you've seen Jim Finley at a presentation tax conference in Utah in 2022, and a press release announcing his company partnering with Uintah Basin Technical College, HuffPost likely wouldn't know what he looks like.

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"He's very much behind the scenes," Kuveke said. "I think he recognizes that he can get a lot more done with his capital, and he can protect his reputation."

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Well pads used for horizontal drilling are seen in the Uinta Basin near Duchesne, Utah, in July.

RICK BOWMER VIA ASSOCIATED PRESS

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‘The best oil we’ve ever seen’

In July 2022, Talbot held court over a meeting of Uinta oil and gas drillers. He said, to deliver a message from his boss: The company’s success in the basin would “lift all ships.”

“You guys are sitting on a jewel of a resource. It’s something that Jim Finley has been trying to tell people for seven or eight years, and finally it’s coming to fruition,” Talbot said. “What drives him is not the financial gain. What drives him is success. He wants everyone to be successful.”

The basin’s “waxy” crude is indeed unique — low in sulfur, acids and metals — and demand is growing for its use in lubricants, makeup products, building materials and other non-

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combustion products. Talbot called it a “world-class resource,” as “pure” a hydrocarbon as they come.

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Finley first arrived in the Uinta in 2008 after his company acquired several leases from El Paso Gas Company. In that meeting, Talbot recalled his and Finley’s first visit to the site on a snowy, subzero day in February of that year.

“I just thought to myself, ‘Jim, there’s plenty of oil in warm places. What are we doing here?’” Talbot said. “That changed quickly.”

What they found were massive hydrocarbon reserves in deep layers known as stacked pays — “formations that were very productive, just waiting for somebody to exploit them,” Talbot said.

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Drilling in the basin began to surge over the next several years. However, production hit a roadblock around 2013, when the five small refineries in Salt Lake City reached their 85,000 barrel-per-day capacity. That’s when Finley and his allies got serious about finding ways to “break the export barrier,” as Finley has put it.

But Uinta’s waxy crude comes with major transportation hurdles. Below 110 degrees, the oil is a sticky semi-solid, meaning it must be heated to transport via train or truck, at added cost. Those challenges meant local refineries would only accept it at a discounted rate.

It was around that time that Finley Resources hired an industry consultant — Talbot didn’t say which one — to study the wax and find potential buyers. “For years, the refineries just told us, ‘Man, this is bad stuff … You need to discount it,’” Talbot said. “What these consultants told us is, ‘This is the best oil we’ve ever seen.’”

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“We are no longer the black sheep of the oil industry,” he added with a chuckle. “Refineries all over the country desire this wax.”

It appears Finley would prefer to ship this waxy crude entirely by rail. He has voiced support for the Uinta Basin Railway, a $3 billion, 88-mile proposed rail line that would connect the remote basin to the national railway system.

The project’s backers see the railway as essential for long-term production growth — and have pushed millions in project costs onto taxpayers. Opponents see it as a “carbon bomb” that threatens U.S. climate goals, scarce water resources and public health.

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A train hauls oil tanker cars near Price, Utah. The proposed Uinta Basin Railway would connect the remote Uinta Basin to the national rail network, allowing producers an easier way to ship crude oil to Gulf Coast refineries.

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The controversial project hit a major snag in August when a U.S. appeals court vacated federal regulators' approval of a key permit, ruling that the Surface Transportation Board failed to properly consider climate and other environmental risks. The court has since rejected a motion from railway supporters to rehear the case, effectively sending the project back to square one. Further jeopardizing the project's future, the U.S. Forest Service has officially withdrawn its approval of a right of way for the railroad to traverse a 12-mile section of the Ashley National Forest.

But Finley isn't one to put all his eggs in one basket. He's been diligently working to expand trucking and existing rail to get more Uinta crude to large out-of-state refineries, where profit margins are higher.

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"Jim is a very respected voice in the oil and gas community in the Uinta basin," said Thomas Holst, a senior energy analyst at the University of Utah who for decades worked for oil giants Chevron and Mobil Oil. "He's not necessarily counting on the rail. The rail would be good, but in the meantime there are other ways to get crude oil from the Uinta Basin to where it can transload on trains that go to the U.S. Gulf Coast."

Environmental groups warn that that effort, much like the proposed Uinta Basin Railway, comes with myriad environmental and public health risks, as it would mean significantly more tanker trucks traversing mountain terrain, as well as oil trains running between Utah and the Gulf Coast.

Last year, Utah crude oil production reached a record high of 52 million barrels — more than 140,000 barrels per day — and Uinta Basin production is forecast to reach as high as 175,000 barrels per day in the second half of 2024, according to a recent economic report from the Utah Geological Survey. Approximately 85% of Utah's oil and gas is extracted from the Uinta.

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'Spaghetti at the wall'

Finley has grown his footprint exponentially since he first arrived in the Beehive State. His two drilling companies, Finley Resources and Uinta Wax Operating LLC (also known as CH4-Finley Operating, LLC), operate across a combined 340,000 acres in the basin, much of it federal land, and are producing approximately 26,000 barrels per day, according to state data. (Only one Uinta operator, XCL Resources, produced more last year.)

At current crude oil prices of around $75 per barrel, that amounts to more than $700 million in pre-tax revenue annually. Finley has said the Uinta has the "best producing rock in all of the United States," and that the rate of return means his companies are able t[illegible] running down to roughly $45 per barrel.

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Among Finley's most strategic moves was purchasing a 50% stake in the Wildcat Loadout Facility near Price, Utah — an acquisition that Talbot called the "most important story in the basin."

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Located on federal land and originally used for shipping coal, the facility is now transferring more than 20,000 barrels of Uinta waxy crude, hauled out of the basin in tanker trucks, onto rail cars bound for Gulf Coast refineries, including ExxonMobil's facility in Baton Rouge, Louisiana — in the heart of the heavily polluted industrial hub widely referred to as "Cancer Alley" — and the Saudi Arabia-owned Motiva refinery in Port Arthur, Texas.

To keep the oil flowing south, Finley Resources is looking to dramatically expand the loadout facility's capacity from 30,000 barrels to 100,000 barrels daily. Colorado Newsline reported in November that the facility has been out of compliance with state pollution rules for the last several years. The president of Wildcat Loadout Management declined to comment on the noncompliance, other than to tell a Colorado Newsline reporter, "You guys need to figure out where you get your information from." (For the record, the publication got its information directly from state regulators.)

If the Bureau of Land Management approves the proposal, the expansion would lead to a dramatic increase in both hazardous truck traffic out of the basin and oil trains running between Utah and the Gulf Coast, including along a 100-mile stretch of the Colorado River and its headwaters. BLM's website currently notes that the project has been "paused," and an agency official told HuffPost that BLM has an "incomplete" understanding of the proposal and that "no one at BLM is actively working on the project at this time."

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Two other area rail loadout facilities, the Price River Terminal and the Savage Terminal, are also eyeing expansions. If all three receive final approval, oil export capacity would soar from a combined 110,000 barrels per day to 260,000 barrels per day, according to a fact sheet that the Center for Biological Diversity and the Southern Utah Wilderness Alliance developed. That could lead to more than 900 oil tanker truck trips out of the basin every day, or one approximately every one and a half minutes, they found.

Environmentalists fear that either route, the Uinta Basin Railway or expanded trucking and transloading, is a disaster waiting to happen — for the global climate, scarce water resources, wildlife, local communities and sensitive archeological sites.



The Utah state Capitol is seen behind an oil refinery on May 12, 2022, in Salt Lake City.

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Landon Newell, a staff attorney for the Southern Utah Wilderness Alliance, said Finley and other Uinta producers have "taken a throw-spaghetti-at-the-wall approach" to massively expand drilling and open up new out-of-state markets. If successful, their plans would deliver a "double whammy" to the environment and area communities, he said.

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"You get huge public health impacts and the oil [illegible]," Newell said. "Certainly there are jobs, certainly there is revenue — royalties and so on — but a lot of the 'benefit' for oil extraction goes elsewhere, and the vast majority of the negatives — health, pollution, so on — are left in the basin."

The Uinta Basin is already plagued with periodic bouts of poor air quality. The fossil fuel industry is the largest local source of ozone-forming pollutants.

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Seth Lyman, an air quality and energy industry expert at Utah State University, said that while Utah's oil and gas sector has gotten better at controlling emissions, there is "good reason to be concerned that pollutant emissions and our air pollution problem would increase in an increased oil and gas production scenario."

"How much it would increase, and what the health effects would be, are outside of what we know right now," he added. "There is not yet oil and gas production in the United States that doesn't lead to significant air pollution impacts."

In 2022, the Environmental Protection Agency reached a $3 million settlement with Crescent Point Energy U.S. Corp. over alleged Clean Air Act violations at its facilities in the Uinta. The agreement came more than two years after Finley Resources and CH4 Energy Six purchased Crescent Point's assets in the Uinta for $525 million.

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Utah leaders have largely embraced Finley's vision for the basin, citing the economic benefits, while those in neighboring Colorado and environmental groups have fought it at every turn, in part due to the risk of an oil spill into the Colorado River, the main water source for approximately 40 million people.

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A Surface Transportation Board analysis found that the increased rail traffic from the Uinta Basin Railway — approximately five trains per day, each of them two miles long — could lead to a train accident about once a year along existing track between Denver and Kyune, Utah, with 25% of those resulting in an oil spill. The executive director for the Seven County Infrastructure Coalition dismissed that risk as "low."

"I've sounded the alarm on the dangers of the Uinta Basin Railway," Sen. Michael Bennet (D-Colo.) wrote in a post on X, formerly Twitter, in November. "Now, the proposed Wildcat Loadout expansion poses similar threats to the Colorado River & local communities. This project would be disastrous for our state."

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Heavy handouts

In their race to exploit the Uinta, drilling companies, fossil fuel-producing counties and Utah elected officials have worked — successfully in some cases — to push costs onto the public.

The Seven County Infrastructure Coalition, an interlocal agency formed in 2014 that comprises seven mineral-rich counties in eastern Utah, has spearheaded the Uinta Basin Railway, as well as several other oil and gas projects in the region. It secured Drexel Hamilton Infrastructure Partners, or DHIP Group, to finance the rail project, and Rio Grand Pacific Corporation to design and operate it.

In 2018, the coalition applied for a $30 million grant from Utah's Permanent Community Impact Fund Board to pay for the design, permitting and legal costs of the project. It was a bold request, given that the fund was set up to distribute royalties from resource extraction on federal lands to pay for improvement projects in communities most heavily affected by drilling and mining — not to advance more fossil fuel projects.

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In 2019, despite concerns from the Utah attorney general's office and other state officials about the legality of using fund dollars for an oil train project, the board awarded $28 million to the Seven County Infrastructure Coalition. The following year, a state audit identified numerous projects, including the Uinta Basin Railway, that it said "raise concerns surrounding

how mineral lease funds are used," and recommended the program be overhauled to ensure money is being directed to projects that mitigate the effects of mineral extraction, rather than boosting private-sector interests. (A separate report from environmental groups in 2021 found that the board had distributed more than $109 million to projects that boosted fossil fuels.)



Keith Heaton, executive director of the Seven County Infrastructure Coalition, discusses the Uinta Basin Railway proposal on July 18, 2023, in Salt Lake City.

RICK BOWMER VIA ASSOCIATED PRESS

Republican state Sen. Ron Winterton, who represents much of the Uinta Basin and is a fierce supporter of the rail project, found a different fix. In early 2021, he introduced a bill to amend the state statute governing the use of mineral lease funds, stripping language that required the funds to be used "for the alleviation of social, economic and public finance impacts resulting from the development of natural resources in this state." Critics saw it as little more than a giveaway to fossil fuel interests, but the legislature passed the bill.

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Few if any Utah elected officials have done more to try to assist Finley and other Uinta drillers. Talbot has called Winterton "a great advocate" of Finley Resources' projects.

Winterton was a member of the Permanent Community Impact Fund Board when it awarded the first $6 million to the Seven County Infrastructure Coalition to design the oil railway, Mother Jones reported. At the time, he was also a consultant for Jones and DeMille Engineering, the very firm that the coalition hired to oversee project management.

In 2019, Winterton sponsored failed legislation that would have eliminated the state's 7.5% sales tax that oil and gas companies pay for equipment and materials used for extraction, The Salt Lake Tribune reported. During a 2022 appearance at a Utah Taxpayers Association conference, Finley bemoaned that Utah doesn't provide sales tax relief to his industry.

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"Utah ought to be a leader in incentivizing fossil fuels," he said. "We need to be sending a signal that Utah is a place to spend your money drilling oil and gas wells."

Winterton did not respond to HuffPost's requests for comment.

"If this project truly were economically viable, its developers would have no need to rely on federal subsidies."

- Sens. Michael Bennet (D-Colo.) and John Hickenlooper (D-Colo.), and Rep. Joe Neguse (D-Colo.)

Early last year, before the courts derailed the Uinta Basin Railway, project backers hatched a plan to get taxpayers to cover millions of dollars' worth of construction costs. In February, the Seven County Infrastructure Coalition passed a resolution giving the railroad a green light to apply for up to $2 billion in low-interest, federally subsidized bonds from the Department of Transportation.

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Railroad developers did not officially submit an application prior to the court ruling, but the bond scheme sought to cover 70% of the railroad's development costs and, according to one tally, would have saved the railroad — but cost taxpayers — an estimated $80 million per year for the life of the bonds.

In a March letter, Bennet joined Sen. John Hickenlooper (D-Colo.) and Rep. Joe Neguse (D-Colo.) in urging Transportation Secretary Pete Buttigieg to deny any future bond request, arguing that it would "irretrievably sink taxpayer dollars into a project that has proven unable to contain its own costs."

"If this project truly were economically viable, its developers would have no need to rely on federal subsidies," the lawmakers wrote.

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The oil and gas sector remains one of the most heavily subsidized industries in the U.S., despite reporting record profits in recent years. Finley's companies have been no exception.

Bailout Watch found that Finley's companies received more than $140 million in COVID-19 relief funds, including a $130 million loan from the Main Street Lending Program, the largest of any oil and gas company, and $11 million from the Paycheck Protection Program. They also benefited hugely from Trump administration-era reductions in royalties, the payments that oil and gas companies make to the federal government to extract oil and gas from federal lands and waters. More than 37,000 federal acres that Finley's companies lease in Utah and Wyoming were approved for royalty relief early in the pandemic.

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Those bailouts appear to have helped Finley continue to grow his Utah operations. His Uinta wells produced approximately 9.4 million barrels of oil in 2022, up from 6.9 million barrels two years prior, according to state data.

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Finley is also a major political donor. Bailout Watch tallied over $600,000 in federal and state election spending over the past two decades. At the federal level, most of Finley's money has gone to Republican candidates and GOP political action committees. In 2022, he gave $5,800 each to Sen. Mike Lee (R-Utah) and the GOP fundraising platform WinRed.

Lee, a fierce supporter of the oil industry, condemned the appeals court's August decision striking down the Uinta Basin Railway's approval. He accused the court of being "influenced by 'woke environmentalism,'" and promised to work with others to "ensure this project moves forward promptly." A month later, the self-proclaimed champion of the Constitution and the rule of law attempted to reverse the court's ruling, introducing an amendment to a military appropriations bill that would have rubber-stamped the rail line and stripped all courts of their ability to review federal approvals of the project.

Lee's amendment ultimately was not included in the spending package adopted in November, but railroad opponents worry similar proposals could turn up in future legislation. Rep. John Curtis (R-Utah) submitted a similar amendment to a 2024 transportation appropriations bill that the House introduced in July. The Utah lawmakers' efforts mirror those of Sen. Joe Manchin (D-W.Va.), who undertook considerable legislative maneuvering last year to greenlight the Mountain Valley Pipeline.

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At a November meeting of the Seven County Infrastructure Coalition, one boa hinted at a possible legislative fix for resurrecting the railway project, but did not elaborate on what that might look like.

Meanwhile, Finley and others are focused on growing Uinta exports without the proposed rail line.

"We're past the point of non-return," Finley said at the Utah Taxpayers Association conference in 2022. He noted that if the export market disappeared and rigs had to shut down, it would take two years of decline before Salt Lake City refineries could accept all the oil coming out of the basin.

“We’re shipping a lot of crude out by rail,” he said. “That will continue to grow.”



A tanker truck transports oil through the Uinta Basin south of Duchesne, Utah, on July 13, 2023.

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A ‘stepping stone’

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Many observers have described the Wildcat Loadout expansion as a backup plan to the Uinta Basin Railway. Deeda Seed, a senior campaigner at the Center for Biological Diversity, see things differently.

“I think it’s always been the plan,” Seed said, referring to the railway. “It’s all of this plan to ramp up production and is working every angle.”

To hear Finley tell it, it is a “stepping stone” to an extraction boom that will eventually demand a rail line.

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During his 2021 presentation to the Seven County Infrastructure Coalition, Finley said existing wells in the basin are having “spectacular” success, and projected that in three years, even without the Uinta Basin Railway, he and other Uinta producers would be exporting 100,000 barrels per day to out-of-state refineries.

“At some point the basin is going to hit a brick wall from a truck-traffic standpoint,” he said. “And to grow the basin to 200,000 or 300,000 barrels a day, which it is fully capable of doing, we’ll have to have the railroad.”

Finley went on to explain that his company is unable to back the railroad financially until export volumes are significantly higher.

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“It is the classic chicken and the egg,” he said. “We can’t commit volumes so that [DHIP Group] can get funding until we actually have the volume. In order to get the volume, we’ve got to have the truck traffic and the existing rail facilities to get us there. But it’s only a stepping stone to, hopefully, what this basin would look like five or 10 years from now.”

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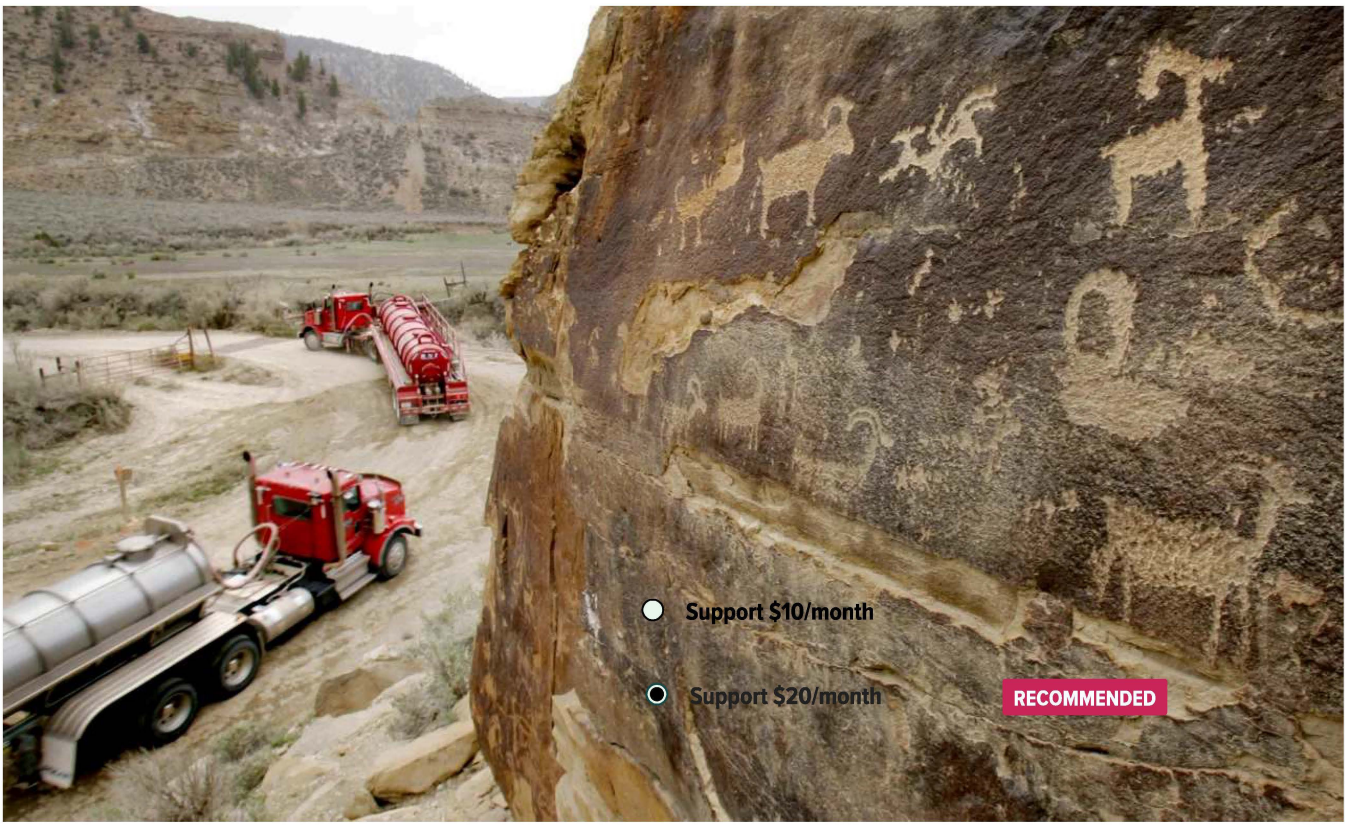
To reach the 100,000-barrel export target, the number of oil tanker trucks traversing a mountainous section of U.S. Highway 191 between the Uinta and rail terminals to the west would roughly triple. The number of train cars hauling oil along the Colorado River and on to the Gulf Coast would also rise drastically, along with the chance of derailments and spills.

Utah lawmakers have funneled tens of millions of dollars in public money toward making that vision a reality. Last session, the Utah legislature approved a request from Winterton, the state senator, for $88 million in funds for road improvements on Highway 191 — investments that Talbot, of Finley Resources, said were key for continued production and export growth.

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Separately, Duchesne County has proposed reconstructing and paving a windy, remote road through Gate Canyon, which would give tanker trucks an alternative route out of the basin through Nine Mile Canyon — a tourist destination with many Indigenous cultural sites that's known as the "world's longest art gallery." The Bureau of Land Management is reviewing the proposal.

"The volume of trucks expected to come down if they succeed in this, on a daily basis, would be a truck every three minutes, which has huge implications for wildlife and the cultural resources in the canyon," Seed said. "It would basically destroy this area."



In this 2008 file photo, tanker trucks pass petroglyphs in Nine Mile Canyon northeast of Wellington, Utah.

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More recently, the Uintah Recreation District requested $27 million in public funds from the Utah Community Impact Board to pay for road improvements around Finley's new frac sand facility, Wildcat Sand. In its application, which the CIB denied in December, the district noted that the roads "have been heavily damaged by trucks accessing a new frac sand processing facility," and that the money is needed to upgrade roads "to withstand the truck traffic it is now experiencing and for public safety."

'Green' fuel or greenwashing?

In his quest to grow basin production, Finley has touted Uinta wax as a "green" material that will outlive other hydrocarbons as the nation transitions to renewable energy sources.

"It might be the last fossil fuel produced in the whole world," he said at the tax conference in 2022.

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At the Seven County coalition meeting, Finley said the company has "taken the word 'crude oil' out of our vocabulary."

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"We drill for wax. We produce wax. We ship wax on rail, and support the wax railroad," he said. "So just to let you know, we don't know much about crude oil anymore."

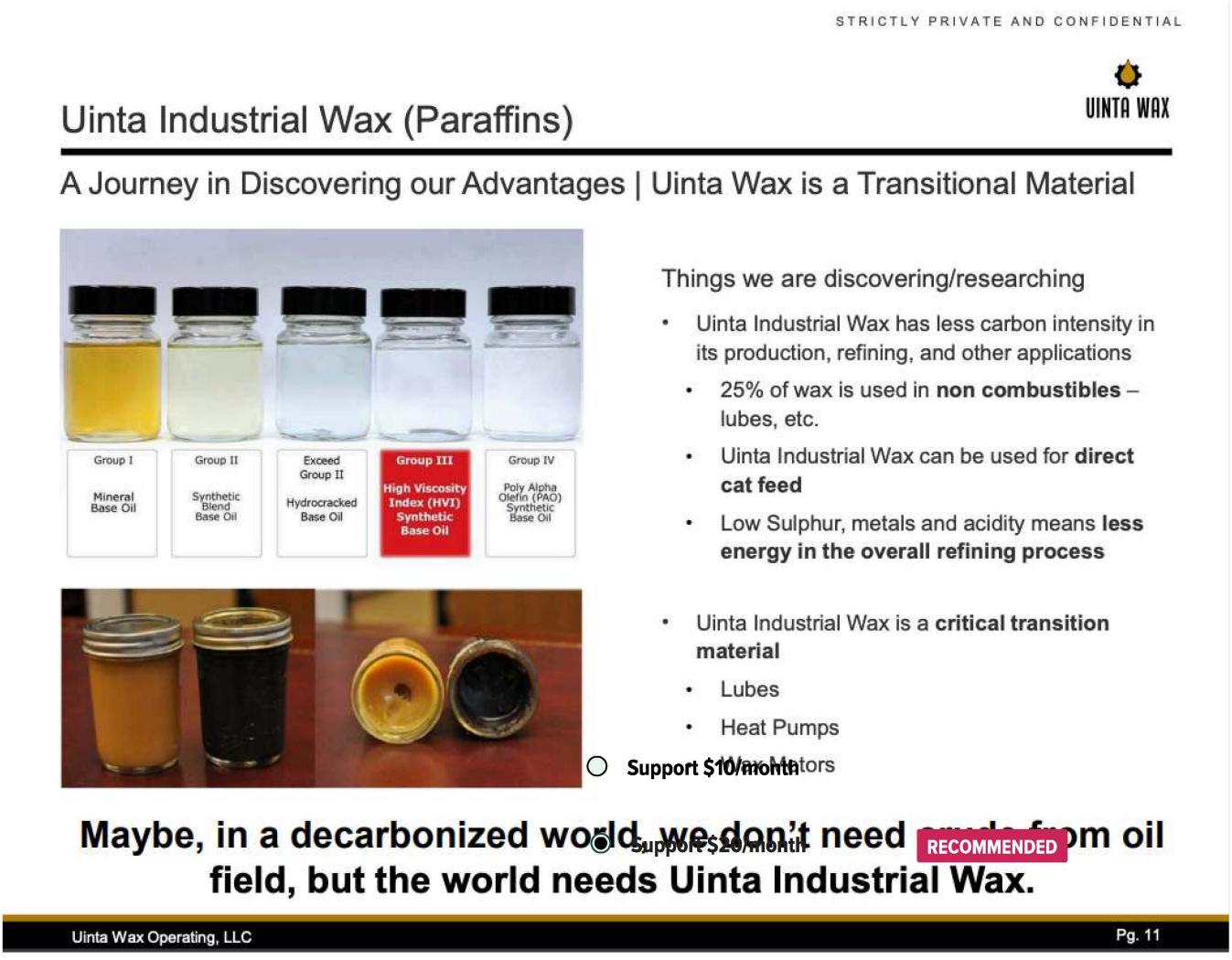
Finley highlighted the wax's use in everything from heat pumps and vehicle thermostats to Carmex lip balm, chewing gum, textiles and bedding. But from what he can infer, it's the growing wind energy sector, which uses the wax for lubricants in wind turbines, that is driving the surge in demand.

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The job of Finley Resources and other Uinta producers is to “show the world that what we produce here in Utah is green,” Finley said. “It’s a good story, and part of what we’ve got to educate everybody on.”

Finley’s attempt to rebrand the material as “industrial wax” is complicated by the fact that the vast majority of what is being produced — approximately 75%, according to Finley — is still being burned for fuel.

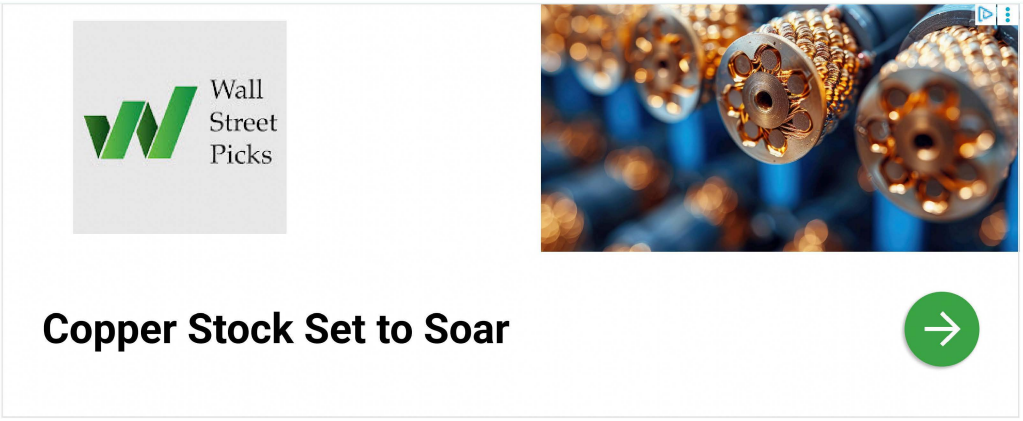


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A slide that Jim Finley, CEO of Finley Resources, showed during a presentation to the Seven County Infrastructure Coalition in 2021.

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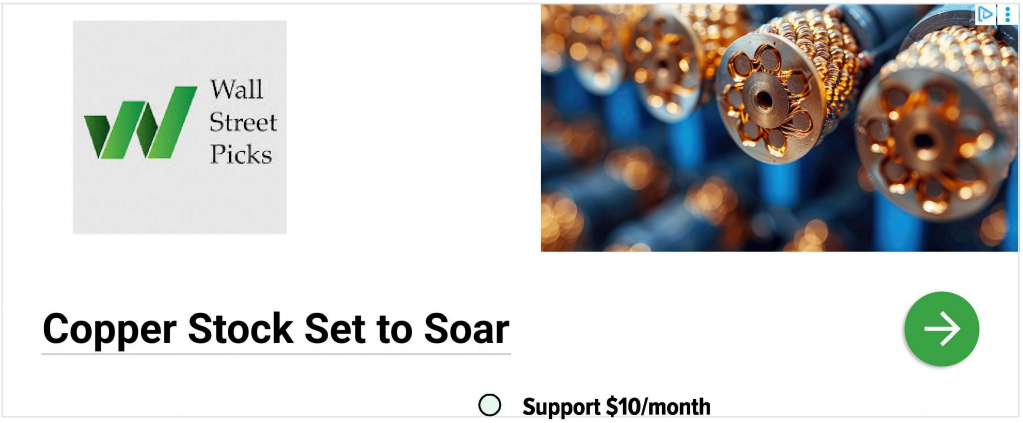


It is also a finite resource. The U.S. Geological Survey estimates there are more than 1.3 trillion barrels of oil in place in the basin, but the waxy crude accounts for only 550 million to 700 million barrels. The rest is dirty tar sands oil and oil shale — resources that are not presently economically viable, but that the industry hopes a railway could eventually help unlock.

Seed pointed out that at the rate the railroad would allow drillers to develop the basin's waxy crude, the resource could be tapped in as little as five to seven years.

"There's also the unavoidable fact that producing that much oil out of the Uinta basin every year, conservatively, according to the [environmental impact statement], will release 53 million metric tons of carbon into the atmosphere," Seed said. "That's a lot."

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Asked about the timeline for draining the basin of crude, Finley, the energy stressed that proven reserves are often inaccurately low.

"I couldn't answer how long it will last," he said of the Uinta crude. "But I will say prolific basins — this basin has been producing since the mid-'40s — have a way of perpetuating and defying some expectations."

Finley and his team are forecasting a multigeneration economic boom that will require an influx of rig workers and truck drivers, as well as new hotels, restaurants and other local business.

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"It's exciting," Talbot said at the event in 2022. "Everybody in this room and your children, and maybe your grandchildren, should benefit from it."

The retired industry professional argued that if the state of Utah were thinking strategically, it would develop the basin's unique resource over time and keep it in the state.

"The path they are on, right now, is to ship all of our good oil out of state. What are we going to replace it with in 20 years?" the retired professional said. "Finley, he's really doing a major disservice if people would think through it."

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EXHIBIT 19



Terminal Expansion Phase 1 Begins

By wpusername4141 March 5, 2025

Fort Worth, Texas – March 5, 2025 Wildcat Midstream, LP is excited to share a series of key developments that mark a transformative step forward for our operations and growth strategy. Wildcat has broken ground on the previously announced Phase 1 of the expansion of the Wildcat Terminal in Helper, Utah.



The design, engineering and permits have been secured, and civil work has begun to lay additional track, activate additional transloaders and construct the required electrical upgrades for the increased volumes.

Phase 1 will increase Wildcats current loading capacity from 42,000 barrels per day to 66,000 barrels per day with an in-service date of July 2025.

Phase 2 of the expansion further increases the capacity to approximately 140,000 barrels per day. Design, engineering, permitting and materials are secure. Estimated in service date of 2Q2026.

Phase 2 will soon be seeking alignment on the commercial agreements/ commitments required to underwrite the investment capital for the project.

Wildcat is the Basin's **only turnkey terminal operator** offering Producers a complete range of logistics services from wellhead to railhead coordinating, trucking, railcar loading, railcar leases, offloading and ultimate market sales.

Wildcat Midstream has also **secured multiple long-term agreements** that will reinforce its premier position in the Uinta Basin. These agreements include a Class 1 rail carrier, the largest rail offloading terminal in Louisiana, and wax sales commitments to a world class refiner on the Gulf Coast, supported by partnerships with key upstream producers in the Uinta Basin. These contracts position Wildcat Midstream for continued growth, fostering greater access to various market centers and optimizing the Producers netbacks for the Uinta Basin's premium-grade waxy crude oil. This marks another important milestone in Wildcat Midstream's mission to support both the producers and local communities in Utah through sustainable growth and long-term value creation.

As part of this expansion effort, Wildcat Midstream has purchased 422 acres of land just to the north of the Wildcat Loadout facility in Helper, UT. This strategic move is expected to bolster the export of the region's unique yellow and black wax crude oil, which has seen production levels double in recent years. Jim Finley, partner of Wildcat Midstream, emphasized the significance of this expansion for the Uinta Basin's economic development, highlighting the positive impact on the Ute Indian Tribe, Carbon County, and the State of Utah. Wildcat Midstream, founded in 2018, is a leading terminal operator in Utah, specializing in the purchasing, marketing, and transloading of Utah Wax. Current operations include 14 transloaders, 1,309 rail cars, three locomotives, and 43 employees split between Carbon County, UT, and Fort Worth, TX.

Additional information can be found on the Wildcat Midstream LP website www.wildcatmidstream.com

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EXHIBIT 20

State of Utah

SPENCER J. COX
Governor

DEIDRE HENDERSON
Lieutenant Governor

Department of
Environmental Quality

Tim Davis
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

DAQE-AN150710006-25

December 4, 2025

Brandon McDowell
Wildcat Midstream LP
1308 Lake Street
Fort Worth, TX 76102
bmcdowell@finleyresources.com

Dear Mr. McDowell:

Re: Approval Order: Modification to Approval Order DAQE-AN150710005-24 to Expand Transloading Operations
Project Number: N150710006

The attached Approval Order (AO) is issued pursuant to the Notice of Intent (NOI) received on August 11, 2025. Wildcat Midstream LP must comply with the requirements of this AO, all applicable state requirements (R307), and Federal Standards.

The project engineer for this action is **Christine Bodell**, who can be contacted at (385) 290-2690 or cbodell@utah.gov. Future correspondence on this AO should include the engineer's name as well as the DAQE number shown on the upper right-hand corner of this letter. No public comments were received on this action.

Sincerely,

Bryce C. Bird
Director

BCB:CB:jg

cc: Southeastern Utah District Health Department

STATE OF UTAH
Department of Environmental Quality
Division of Air Quality

APPROVAL ORDER
DAQE-AN150710006-25
Modification to Approval Order DAQE-AN150710005-24 to Expand Transloading Operations

Prepared By
Christine Bodell, Engineer
(385) 290-2690
cbodell@utah.gov

Issued to
Wildcat Midstream LP - Petroleum Transloading Facility

Issued On
December 4, 2025

Issued By



Bryce C. Bird
Director
Division of Air Quality

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GENERAL INFORMATION

CONTACT/LOCATION INFORMATION

Owner Name
Wildcat Midstream LP

Source Name
Wildcat Midstream LP - Petroleum Transloading Facility

Mailing Address
1308 Lake Street
Fort Worth, TX 76102

Physical Address
5441 Consumer Road
Helper, UT 84526

Source Contact
Name: Brandon McDowell
Phone: (720) 846-1270
Email: bmcdowell@finleyresources.com

UTM Coordinates
507,140 m Easting
4,390,088 m Northing
Datum NAD83
UTM Zone 12

SIC code 5171 (Petroleum Bulk Stations & Terminals)

SOURCE INFORMATION

General Description
Wildcat Midstream LP (Wildcat) currently owns/operates an industrial wax (crude oil) trans-loading facility near Helper, Carbon County. The facility receives crude oil from highway petroleum tanker trucks that is unloaded through permanently affixed above-ground electric pumps. The oil is either transferred directly to rail tanker cars using portable transloaders or stored on site in one of four above-ground heated internal-floating-roof storage tanks prior to being loaded into rail tanker cars. The facility processes up to 73,000,000 barrels (1 barrel = 42 gallons) of crude oil per year.

NSR Classification
Minor Modification at Minor Source

Source Classification
Located in Attainment Area
Carbon County
Airs Source Size: B

Applicable Federal Standards
NSPS (Part 60), A: General Provisions
NSPS (Part 60), Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984

Project Description
Wildcat has requested a modification to AO DAQE-AN150710005-24, dated May 21, 2024, to increase the throughput of industrial wax (crude oil) by 100,000 barrels per day (36,500,000 barrels per year).

Per Condition II.B.5.a of the 2024 AO, Wildcat is currently permitted to transload a throughput of no more than 36,500,000 barrels of industrial wax (crude oil) per rolling 12-month period. Per Condition II.B.6.a of the 2024 AO, Wildcat is only permitted to load the railcars on site directly from the industrial wax (crude oil) storage tanks.

Wildcat has requested that the additional 36,500,000 barrels per year be loaded into railcars directly from delivery trucks via portable transloaders. Therefore, VOC emissions from loading operations from crude oil storage tanks will continue to be controlled via vapor capture line to the combustor, as required by Condition II.B.6.c of the 2024 AO. The VOC emissions from the transloading operations for the additional 36,500,000 barrels per year will be controlled via vapor balancing.

SUMMARY OF EMISSIONS

The emissions listed below are an estimate of the total potential emissions from the source. Some rounding of emissions is possible.

Criteria Pollutant	Change (TPY)	Total (TPY)
CO_2 Equivalent	0	12453.00
Carbon Monoxide	0	11.68
Nitrogen Oxides	0	8.60
Particulate Matter - PM_{10}	2.44	5.63
Particulate Matter - $PM_{2.5}$	0.24	1.24
Sulfur Dioxide	0	0.43
Volatile Organic Compounds	12.48	46.22

Hazardous Air Pollutant	Change (lbs/yr)	Total (lbs/yr)
Benzene (Including Benzene From Gasoline) (CAS #71432)	256	826
Generic HAPs (CAS #GHAPS)	20	88
Hexane (CAS #110543)	4840	15860
Toluene (CAS #108883)	330	1092
	Change (TPY)	**Total (TPY)**
Total HAPs	2.72	8.93

SECTION I: GENERAL PROVISIONS

I.1	All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]

I.2	The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]
I.3	Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]
I.4	All records referenced in this AO or in other applicable rules, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the two-year period prior to the date of the request. Unless otherwise specified in this AO or in other applicable state and federal rules, records shall be kept for a minimum of two (2) years. [R307-401-8]
I.5	At all times, including periods of startup, shutdown, and malfunction, owners and operators shall, to the extent practicable, maintain and operate any equipment approved under this AO, including associated air pollution control equipment, in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Director which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. All maintenance performed on equipment authorized by this AO shall be recorded. [R307-401-4]
I.6	The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]
I.7	The owner/operator shall comply with UAC R307-150 Series. Emission Inventories. [R307-150]

SECTION II: PERMITTED EQUIPMENT

II.A THE APPROVED EQUIPMENT

II.A.1	**Petroleum Transloading Facility**
II.A.2	**One (1) Vapor Combustor Unit** 97% Destruction Efficiency
II.A.3	**One (1) 5.6 MMBtu/hr Tank Heater** Fuel: Natural Gas
II.A.4	**Two (2) Conical Internal-Floating-Roof Tanks** Contents: Industrial wax (crude oil) Capacity: 80,000 barrels each NSPS Applicability: Subpart Kb MACT Applicability: None
II.A.5	**Pump Engines** Electrically Operated - listed for informational purposes only -
II.A.6	**Portable Transloaders**

SECTION II: SPECIAL PROVISIONS

II.B REQUIREMENTS AND LIMITATIONS

II.B.1	**Site-Wide Requirements**
II.B.1.a	Unless otherwise specified in this AO, the owner/operator shall not allow visible emissions to exceed 10% opacity. [R307-401-8]
II.B.1.a.1	Opacity observations of emissions from stationary sources shall be conducted in accordance with 40 CFR 60, Method 9. [R307-401-8]
II.B.2	**Haul Road and Fugitive Dust Requirements**
II.B.2.a	The owner/operator shall not allow visible emissions from haul roads and fugitive dust sources on site to exceed 20% opacity. [R307-401-8]
II.B.2.a.1	Opacity observations of fugitive dust from intermittent sources shall be conducted according to 40 CFR 60, Appendix A, Method 9; however, the requirement for observations to be made at 15-second intervals over a six-minute period shall not apply. The number of observations and the time period shall be determined by the length of the intermittent source. For fugitive dust generated by mobile sources, visible emissions shall be measured at the densest point of the plume but at a point not less than one-half vehicle length behind the vehicle and not less than one-half the height of the vehicle. [R307-401-8]
II.B.2.b	The owner/operator shall pave the entry haul road for no less than 1,320 feet (0.25 miles) in length. The owner/operator shall not exceed 1,320 feet (0.25 miles) of haul roads on site. [R307-401-8]
II.B.2.b.1	The paved road length shall be determined through source records or GPS measurements. [R307-401-8]
II.B.2.c	An operational sweeper and water truck shall be made available during each operating day. The owner/operator shall sweep and flush with water all the paved haul roads on site to maintain opacity limits listed in this AO. If the temperature is below freezing, the owner/operator shall continue to sweep the road but may stop flushing the paved haul roads with water. Flushing the paved haul road with water shall resume when the temperature is above freezing. If the haul roads are covered with snow or ice, the owner/operator may stop sweeping the paved haul roads. Sweeping the paved haul roads shall resume when the haul roads are cleared from snow and ice. [R307-401-8]
II.B.2.c.1	Records of sweeping and water application shall be kept for all periods when the plant is in operation. The records shall include the following items: A. Date and time treatments were made B. Number of treatments made and quantity of water applied C. Rainfall amount received, if any D. Records of temperature, if the temperature is below freezing E. Records shall note if the paved haul roads are covered with snow or ice. [R307-401-8]

II.B.3	**Vapor Combustor Unit Requirements**
II.B.3.a	The vapor combustor unit shall operate with a continuous pilot flame and be equipped with an auto-igniter. [R307-401-8]
II.B.3.b	The vapor combustor unit shall operate with no visible emissions. [R307-401-8]
II.B.3.b.1	Visual determination of emissions from the vapor combustor unit shall be conducted according to 40 CFR 60, Appendix A, Method 22. [R307-401-8]
II.B.3.c	The owner/operator shall install a vapor combustor unit that is certified to meet a VOC destruction efficiency of no less than 97%. [R307-401-8]
II.B.3.c.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of the manufacturer's emissions guarantee for the installed vapor combustor unit. [R307-401-8]
II.B.3.d	The owner/operator shall operate the vapor combustion unit according to the manufacturer's recommendations. [R307-401-8]
II.B.4	**Hot Oil Heater Requirements**
II.B.4.a	The owner/operator shall use only pipeline-quality natural gas as fuel in the heater. [R307-401-8]
II.B.5	**Storage Tank (Storage Vessel) Requirements**
II.B.5.a	The owner/operator shall keep the storage tank thief hatches and other tank openings closed and sealed except during tank unloading or other maintenance activities. [R307-401-8]
II.B.5.b	At least once each month, the owner/operator shall visually inspect, through manholes and roof hatches, each internal floating roof seal and closed vent system (including tank openings, thief hatches, and bypass devices) for defects. Records of inspections shall include the date of the inspection and the results of the inspection. [R307-401-8]
II.B.5.c	The owner/operator shall load the storage tanks on site by the use of bottom filling or a submerged fill pipe. [R307-401-8]
II.B.6	**Liquid Loading Requirements**
II.B.6.a	The owner/operator shall not exceed a throughput of 73,000,000 barrels (1 barrel = 42 gallons) of crude oil per rolling 12-month period. [R307-401-8]
II.B.6.a.1	The owner/operator shall: A. Determine the crude oil throughput with process flow meters and/or sales records. B. Record crude oil throughput on a daily basis. C. Use the monthly throughput data to calculate a new 12-month total by the 20th day of each month using data from the previous 12 months. D. Keep the throughput records for all periods the plant is in operation. [R307-401-8]
II.B.6.b	The owner/operator shall load the railcars on site by the use of bottom filling or a submerged fill pipe. [R307-401-8]
II.B.6.c	The owner/operator shall only load the railcars on site directly from the crude oil storage tanks or from tanker trucks that are certified for the NSPS level annual leak test. [R307-401-8]

II.B.6.c.1	To determine compliance with the above condition, the owner/operator shall maintain records of annual leak test certifications. [R307-401-8]
II.B.6.d	If transloading crude oil from the storage tanks, the owner/operator shall control VOC emissions during railcar loading operations at all times by using a vapor capture line. The vapor capture line shall be connected from the railcar to the vapor combustor. [R307-401-8]
II.B.6.e	If transloading crude oil from tanker trucks, the owner/operator shall connect a vapor balance line to the receiving and delivery vessels prior to venting to the atmosphere during on-site loading operations. The vapor balance line shall be used at all times during loading operations when transloading from tanker trucks. [R307-401-8]
II.B.6.f	The owner/operator shall operate each vapor balance system according to the manufacturer's recommendations. [R307-401-8]
II.B.6.f.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of the manufacturer's recommendations for each installed vapor balance system. [R307-401-8]
II.B.7	**Monitoring Requirements of Fugitive Emissions (Leak Detection and Repair)**
II.B.7.a	The owner/operator shall develop a fugitive emissions monitoring plan. At a minimum, the plan shall include: A. Monitoring frequency B. Monitoring technique and equipment C. Procedures and timeframes for identifying and repairing leaks D. Recordkeeping practices E. Calibration and maintenance procedures. [R307-401-8]
II.B.7.a.1	The plan shall address monitoring for "difficult-to-monitor" and "unsafe-to-monitor" components. [R307-401-8]
II.B.7.b	The owner/operator shall conduct monitoring surveys on site to observe each "fugitive emissions component" for "fugitive emissions." A. "Fugitive emissions component" means any component that has the potential to emit fugitive emissions of VOC, including but not limited to valves, connectors, pressure relief devices, open-ended lines, flanges, covers, and closed vent systems, thief hatches or other openings, compressors, instruments, and meters B. "Fugitive emissions" are considered any visible emissions observed using optical gas imaging or a Method 21 instrument reading of 500 ppm or greater. [R307-401-8]

II.B.7.b.1	Monitoring surveys shall be conducted according to the following schedule: A. No later than 60 days after startup of production, as defined in 40 CFR 60.5430a B. Semiannually after the initial monitoring survey. Consecutive semiannual monitoring surveys shall be conducted at least four (4) months apart C. Annually after the initial monitoring survey for "difficult-to-monitor" components D. As required by the owner/operator's monitoring plan for "unsafe-to-monitor" components. [R307-401-8]
II.B.7.b.2	Monitoring surveys shall be conducted using one or both of the following to detect fugitive emissions: A. Optical gas imaging (OGI) equipment. OGI equipment shall be capable of imaging gases in the spectral range for the compound of highest concentration in the potential fugitive emissions B. Monitoring equipment that meets U.S. EPA Method 21, 40 CFR Part 60, Appendix A. [R307-401-8]
II.B.7.c	If fugitive emissions are detected at any time, the owner/operator shall repair the fugitive emissions component as soon as possible but no later than 15 calendar days after detection. If the repair or replacement is technically infeasible, would require a vent blowdown, a well shutdown, or a well shut-in, or would be unsafe to repair during operation of the unit, the repair or replacement must be completed during the next well shutdown or a well shut-in, after an unscheduled, planned, or emergency vent blowdown, or within 24 months, whichever is earlier. [R307-401-8]
II.B.7.c.1	The owner/operator shall resurvey the repaired or replaced fugitive emissions component no later than 30 calendar days after the fugitive emissions component was repaired.[R307-401-8]
II.B.7.d	The owner/operator shall maintain records of the fugitive emissions monitoring plan, monitoring surveys, repairs, and resurveys. [R307-401-8]

PERMIT HISTORY

This Approval Order shall supersede (if a modification) or will be based on the following documents:

Supersedes	AO DAQE-AN150710005-24 dated May 21, 2024
Is Derived From	NOI dated August 11, 2025

ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by Environmental Protection Agency to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - Title 40 of the Code of Federal Regulations Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ/UDAQ	Division of Air Quality
DAQE	This is a document tracking code for internal Division of Air Quality use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - Title 40 of the Code of Federal Regulations 52.21 (b)(49)(i)
GWP	Global Warming Potential - Title 40 of the Code of Federal Regulations Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/YR	Pounds per year
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
VOC	Volatile organic compounds

EXHIBIT 21

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The Salt Lake Tribune

Trump administration fast-tracks oil transport expansion in eastern Utah

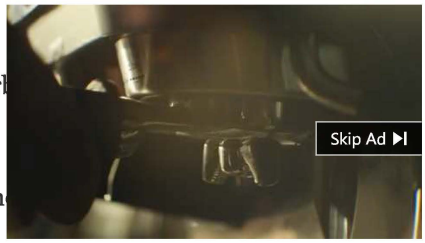
The Bureau of Land Management approved the expansion of the Wildcat Loadout Facility after an expedited review.



(Francisco Kjolseth | The Salt Lake Tribune) Crude oil is transferred from tanker trucks to rail cars parked at the Wildcat Loadout, now controlled by Finley Resources, a Texas-based oil producer. The old coal-handling facility outside Helper, Utah has been repurposed for transloading oil that is trucked from the Uinta Basin and ultimately shipped to Gulf Coast refineries. The Bureau of Land Management approved an expansion of the facility on Thursday, July 3, 2025.

By Brooke Larsen | July 7, 2025, 6:00 a.m. | Updated: 2:10 p.m.

Add as Preferred Source Comment

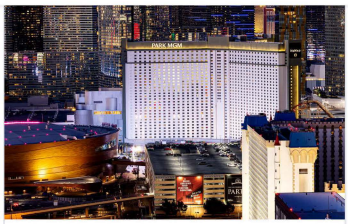


The Bureau of Land Management approved the expansion of an oil transloading facility in Carl review under President Trump's "national energy emergency" declaration.

The expansion of the Wildcat Loadout Facility, which was approved Thursday, will ramp up th producers can transport out of the Uinta Basin by 80,000 barrels per day.

Currently, oil tanker trucks haul 20,000 barrels of oil from the Uinta Basin down the remote, windy U.S. Highway 191 to Wildcat's facility daily. There, the oil is transferred from trucks to rail cars that travel adjacent to the Colorado River for over 100 miles.

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With the expansion, the facility will load 100,000 barrels of oil onto trains heading for the Gulf Coast each day, according to the BLM's environmental analysis. The oil trains consist of 104 rail cars, the largest train length possible on the Union Pacific route.

This increase will also require roughly 345 oil tanker truck deliveries through Indian Canyon daily, according to BLM's review.



(Francisco Kjolseth | The Salt Lake Tribune) Tanker trucks carry oil through Utah's Indian Canyon on U.S. Highway 191 on Aug. 5, 2022 from the Uinta Basin to the Wildcat Loadout, now controlled by Finley Resources, a Texas-based oil producer. The old coal-handling facility outside Helper has been re shipped to Gulf Coast refineries. The Bureau of Land Management approved an expansion of the facility on Thursday, July 3, 2025

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"Responsible energy development plays a key role in supporting local communities and nation District Manager Elijah Waters in a press release. "This project reflects our commitment to adv ensuring careful stewardship of Utah's public lands."

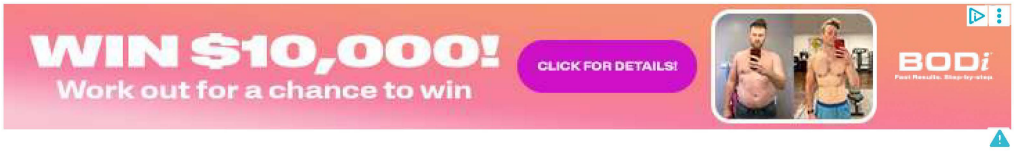
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The BLM gave Coal Energy Group 2 LLC, the owner of the loadout facility, the go ahead to expand after a 16-day review with no public input process.

Environmental groups and Colorado leaders sent letters to the BLM and the Interior Secretary expressing concerns.

“Greatly increased oil train traffic next to the Colorado River and its tributaries for over a hundred miles risks contamination of the water source for tens of millions of people and the economic lifeblood of the region’s businesses, ranches, and farms,” said lawyers representing Eagle County in a letter.

Sen. Michael Bennet and Rep. Joe Neguse of Colorado also released a statement, saying, “There is no credible energy emergency to justify bypassing public involvement and environmental safeguards.”



Environmental analyses typically take months to complete and allow for public input. That changed earlier this year when Trump declared a “national energy emergency” and opened doors to fast-track the procedures normally required under the National Environmental Policy Act and other federal legislation.

“The integrity and expansion of our Nation’s energy infrastructure — from coast to coast — is an immediate and pressing priority for the protection of the United States’ national and economic security," the executive order said.

Fifteen states have filed a lawsuit against Trump’s energy emergency, arguing both the declaration and agencies’ actions on it are unlawfully bypassing “critical ecological, historical, and cultural resource review.”

Oil production has hit record levels in recent years. In March 2024, the U.S. Energy Information Administration found that the U.S. had produced more crude oil than any nation ever for the previous six years in a row. The U.S. has been a net exporter of oil since 2020 and hit record exports in 2024.

Utah also saw record production last year, with 93% of the 65 million barrels produced coming from the Uinta Basin.



The Salt Lake Tribune DONATE DONATE



(Francisco Kjolseth | The Salt Lake Tribune) Crude oil is transferred from tanker trucks to rail cars parked at the Wildcat Loadout, now controlled by Finley Resources, a Texas-based oil producer. The old coal-handling facility outside Helper, Utah has been repurposed for transloading oil that is trucked from the Uinta Basin and ultimately shipped to Gulf Coast refineries. The Bureau of Land Management approved an expansion of the facility on Thursday, July 3, 2025.

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The BLM considered an expansion of Wildcat in 2023, but the company failed to provide BLM with needed information for the environmental analysis, so the agency terminated the review process.

The company then submitted a request in writing to the BLM on May 1 to use the alternative arrangements for review under Trump's energy emergency.

Environmental groups question the company's sudden urgency since it previously stopped participating in the environmental review process.

"This project, which was slow walked for years by the company itself up until last year, has now magically transitioned into an energy emergency," said Landon Newell, attorney at the Southern Utah Wilderness Alliance.

Finley Resource and the BLM did not respond to The Tribune's requests for comment.

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The Wildcat Loadout Facility is a key piece in the expansion of oil drilling in the Uinta Basin. Ji
prominent player in the Uinta Basin oil fields, bought a 50% stake in the Wildcat Loadout five

"That story is the most important story in the basin right now," Brent Talbot, president of Finley Resources, said at a Utah Division of Oil, Gas and Mining meeting in 2022.

Finley Resources has allowed Uinta Basin oil drillers to use the Wildcat facility at cost to help increase production from the regio
and build up producers' bargaining power, according to minutes from a 2021 meeting of the Seven County Infrastructure
Coalition, which includes Carbon and Uintah Counties.

The Salt Lake Tribune DONATE DONATE



(Francisco Kjolseth | The Salt Lake Tribune) Crude oil is transferred from tanker trucks to rail cars parked at the Wildcat Loadout, now controlled by Finley Resources, a Texas-based oil producer. The old coal-handling facility outside Helper, Utah has been repurposed for transloading oil that is trucked from the Uinta Basin and ultimately shipped to Gulf Coast refineries. The Bureau of Land Management approved an expansion of the facility on Thursday, July 3, 2025.

As oil refining capacity maxes out in Salt Lake City, Uinta Basin oil drillers have been pushing for infrastructure, such as the Uinta Basin Railway, that will increase transportation capacity.

While the Uinta Basin Railway faces additional hurdles, the Wildcat expansion serves as another pathway to ramp up transport of oil from the Uinta Basin.

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EXHIBIT 22

def

12/10/2025

Dual Class I-served oil terminal to double capacity by late 2026



Located in the heart of the Uinta Basin in Wellington, Utah, the Price River Terminal is served by BNSF Railway and Union Pacific Railroad. The crude-by-rail terminal's daily capacity will be doubled from 70,000 to 140,000 barrels.

PRICE RIVER TERMINAL

By Jeff Stagl, Managing Editor

The Uinta Basin in northeastern Utah is a large geological region with rich crude oil and natural gas deposits. And demand for the basin's oil is increasing.

To that end, oil exploration and production company FourPoint Resources LLC recently committed to secure 50,000 barrels of oil per day from the Price River Terminal in Wellington, Utah, to meet its needs. Served by BNSF Railway and

Union Pacific Railroad, the crude-by-rail terminal is the only energy transload facility in eastern Utah.

But the terminal currently can only handle 70,000 barrels per day. That's why FourPoint Resources has forged an agreement with Price River Terminal's owner/operator Energy Transfer LP to double the facility's daily export capacity to 140,000 barrels.



The expansion calls for constructing a new continuous loop track to streamline rail logistics and a tank-car load rack designed to load 140,000 barrels per day.

UNION PACIFIC RAILROAD

Announced in early October, the terminal expansion calls for constructing a new continuous loop track to streamline rail logistics and a tank-car load rack designed to load 140,000 barrels per day. Terminal enhancements also will include nine new rail loading arms, four additional truck offload lanes and upgraded pump capacity to accelerate and improve truck offloading operations.

The project will further bolster transportation infrastructure and boost takeaway capacity out of the basin, FourPoint Resources officials say. That, in turn, will help expand market access, enabling the company to better meet growing demand for the region's high-quality crude.

By expanding terminal capacity and optimizing logistics across the supply chain, both Energy Transfer and FourPoint Resources expect to be better positioned to serve refiners across the country and support the next phase of the basin's growth.

"Due to the increase in production volumes expected throughout the basin and [us] dedicating up to 50,000 barrels to move through the terminal daily, Energy Transfer has committed to this infrastructure expansion," said FourPoint Resources Director of Corporate Communications Jenna Samek in an email. "The project is expected to start immediately subject to all necessary third party and government approvals, with a target completion of fourth-quarter 2026."

The expansion also involves adding a new heated storage tank and two additional 6,000-foot storage unit tracks at the terminal to significantly increase storage capacity.

As the energy landscape continues to shift, the Uinta Basin has emerged as one of the few U.S. oil regions that's positioned for meaningful production growth, said FourPoint Resources Chief Operating Officer Eric Eichler in a press release.

"Unlike other major U.S. basins facing declining output, the Uinta Basin is a uniquely resource-rich region with a long runway of remaining tier-one drilling locations," he said. "The basin offers exceptional development potential, with strong well performance, multiple stacked horizontal targets, and competitive well costs — characteristics comparable to what we see in the Permian Basin."

The Uinta Basin also poses significant potential for natural gas development, FourPoint Resources officials say.

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EXHIBIT 23

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Governor

DEIDRE HENDERSON
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Department of
Environmental Quality

Tim Davis
Interim Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

DAQE-AN148620004-25

March 27, 2025

Justin Ray
Price River Terminal, LLC
1300 Main Street
Houston, TX 77002
justin.ray@energytransfer.com

Dear Mr. Ray:

Re: Approval Order: Modification to Approval Order DAQE-AN148620003-20 to Increase Transloading Limits and Add a Storage Tank
Project Number: N148620004

The attached Approval Order (AO) is issued pursuant to the Notice of Intent (NOI) received on September 26, 2023. Price River Terminal, LLC must comply with the requirements of this AO, all applicable state requirements (R307), and Federal Standards.

The project engineer for this action is **Dylan Frederick**, who can be contacted at (385) 306-6529 or dfrederick@utah.gov. Future correspondence on this AO should include the engineer's name as well as the DAQE number shown on the upper right-hand corner of this letter. No public comments were received on this action.

Sincerely,

Bryce C. Bird
Director

BCB:DF:jg

cc: Southeastern Utah District Health Department

STATE OF UTAH
Department of Environmental Quality
Division of Air Quality

APPROVAL ORDER
DAQE-AN148620004-25
Modification to Approval Order DAQE-AN148620003-20 to Increase Transloading Limits and Add a Storage Tank

Prepared By
Dylan Frederick, Engineer
(385) 306-6529
dfrederick@utah.gov

Issued to
Price River Terminal, LLC - Oil Transloading Facility

Issued On
March 27, 2025

Issued By



Bryce C. Bird
Director
Division of Air Quality

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GENERAL INFORMATION

CONTACT/LOCATION INFORMATION

Owner Name
Price River Terminal, LLC

Source Name
Price River Terminal, LLC - Oil Transloading Facility

Mailing Address
1300 Main Street
Houston, TX 77002

Physical Address
6000 East Wash Plant Road
Wellington, UT 84542

Source Contact
Name: Justin Ray
Phone: (936) 402-4860
Email: justin.ray@energytransfer.com

UTM Coordinates
525,464 m Easting
4,375,301 m Northing
Datum NAD83
UTM Zone 12

SIC code 4226 (Special Warehousing & Storage, NEC)

SOURCE INFORMATION

General Description
Price River Terminal, LLC (PRT) operates a transloading facility. The facility transfers crude oil from tanker trucks to oil storage tanks and then to railcars, which are shipped to various crude oil refineries throughout the United States. PRT also has the ability to load crude oil directly from tanker trucks to railcars. Railcars are filled and stored on-site until approximately 90 railcars have been filled. The railcars are then connected to a locomotive engine and transported via rail to customers.

NSR Classification
Minor Modification at Minor Source

Source Classification
Located in Attainment Area
Carbon County
Airs Source Size: B

Applicable Federal Standards
NSPS (Part 60), A: General Provisions
NSPS (Part 60), Kb: Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced After July 23, 1984
NSPS (Part 60), Kc: Standards of Performance for Volatile Organic Liquid Storage Vessels

Project Description
PRT requested approval to install and operate a new liquid storage tank and natural gas-fired heater, as well as increase the daily limit on crude oil transloading. The storage tank has a capacity of 120,000 barrels, and the tank heater is rated at 4 MMBtu per hour and will be operated at 8,760 hours per year. PRT has requested to increase the annual limits of crude oil transloaded through the storage tanks from 14,600,000 barrels to 43,800,000 barrels and to decrease the annual limit of crude oil transloaded through mobile operations from 10,400,000 barrels to 3,650,000 barrels. This is the equivalent of 120,000 barrels transloaded through storage tanks daily and an additional 10,000 barrels transloaded through mobile operations daily.

SUMMARY OF EMISSIONS

The emissions listed below are an estimate of the total potential emissions from the source. Some rounding of emissions is possible.

Criteria Pollutant	Change (TPY)	Total (TPY)
CO_2 Equivalent	1083.74	43658.00
Carbon Monoxide	1.80	62.33
Nitrogen Oxides	2.14	24.56
Particulate Matter - PM_{10}	-7.31	4.55
Particulate Matter - $PM_{2.5}$	-3.36	1.18
Sulfur Dioxide	0.02	0.34
Volatile Organic Compounds	47.72	80.56

Hazardous Air Pollutant	Change (lbs/yr)	Total (lbs/yr)
Generic HAPs (CAS #GHAPS)	-370	62
Hexane (CAS #110543)		1080
	Change (TPY)	**Total (TPY)**
Total HAPs	0.35	0.57

SECTION I: GENERAL PROVISIONS

I.1	All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]
I.2	The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]
I.3	Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]
I.4	All records referenced in this AO or in other applicable rules, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the two-year period prior to the date of the request. Unless otherwise specified in this AO or in other applicable state and federal rules, records shall be kept for a minimum of two years. [R307-401-8]

I.5	At all times, including periods of startup, shutdown, and malfunction, owners and operators shall, to the extent practicable, maintain and operate any equipment approved under this AO, including associated air pollution control equipment, in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Director which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. All maintenance performed on equipment authorized by this AO shall be recorded. [R307-401-4]
I.6	The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]
I.7	The owner/operator shall comply with UAC R307-150 Series. Emission Inventories. [R307-150]
I.8	The owner/operator shall submit documentation of the status of construction or modification to the Director within 18 months from the date of this AO. This AO may become invalid if construction is not commenced within 18 months from the date of this AO or if construction is discontinued for 18 months or more. To ensure proper credit when notifying the Director, send the documentation to the Director, attn.: NSR Section. [R307-401-18]

SECTION II: PERMITTED EQUIPMENT

II.A THE APPROVED EQUIPMENT

II.A.1	**Crude Oil Transloading Facility**
II.A.2	**Three Oil Storage Tanks (one NEW)** Maximum Capacities: one 88,300 bbl and two 120,000 bbl Tank VOC Control Type: Floating Roofs
II.A.3	**One Flare** Maximum Capacity: 0.48 MMBTU/hr Contains: Blower Control Efficiency: 98% Controls: Transloading activities to railcars
II.A.4	**Five Adsorption Units** Maximum Flowrate: 150 acfm Equipped with a breakthrough monitor Controls: Direct Transloading from trucks to railcars
II.A.5	**Three Tank Heaters (one NEW)** Maximum Rated Capacity: less than 5 MMBtu/hr each Fuel: Natural Gas
II.A.6	**One Diesel Storage Tank*** Maximum Tank Capacity: 1,000 gallons *Tank is noted for informational purposes only.
II.A.7	**One Gasoline Storage Tank*** Maximum Tank Capacity: 500 gallons *Tank is noted for informational purposes only.

II.A.8	**Loading/Unloading Racks** Controls: Fixed transloading - Flare Mobile transloading - Carbon adsorption units

SECTION II: SPECIAL PROVISIONS

II.B REQUIREMENTS AND LIMITATIONS

II.B.1	**Site-Wide Requirements**
II.B.1.a	The owner/operator shall not exceed the following processing limitations: A. 43,800,000 barrels (bbls) of crude oil processed through the oil storage tanks and transloaded to railcars per rolling 12-month period B. 3,650,000 bbls of crude oil transloaded to railcars through mobile operations per rolling 12-month period. [R307-401-8]
II.B.1.a.1	The owner/operator shall: A. Calculate a new 12-month total by the 20th day of each month using data from the previous 12 months B. Determine site-wide crude oil transloading by examination of company and/or customer billing records C. Keep records of tank versus mobile crude oil railcar loading individually on a daily basis D. Keep transloading records for all periods the plant is in operation. [R307-401-8]
II.B.1.b	The owner/operator shall control VOC emissions during rail car loading operations from storage tanks at all times by using a vapor capture line. The vapor capture line shall be connected from the railcar loading operations to the flare. [R307-401-8]
II.B.1.c	The owner/operator shall route all emissions from all direct mobile loading to railcar operations to a carbon adsorption drum prior to exhausting the air to the atmosphere. [R307-401-8]
II.B.1.d	The owner/operators shall replace the carbon in the affected adsorber drum upon activation of the breakthrough monitor. [R307-401-8]
II.B.1.e	The owner/operator shall: A. Replace the carbon in each adsorber drum at a minimum of once annually B. Keep records of adsorber drum carbon replacement and maintain the records onsite. [R307-401-8]
II.B.1.f	Unless otherwise specified in this AO, the owner/operator shall not allow visible emissions from any stationary point or fugitive emission source on site to exceed 10% opacity. [R307-401-8]

II.B.1.f.1	Opacity observations of emissions from stationary sources shall be conducted while in operation in accordance with 40 CFR 60, Appendix A, Method 9. [R307-401-8]
II.B.1.g	The owner/operator shall only use natural gas as fuel in the storage tank heaters. [R307-401-8]
II.B.2	**Tank Requirements**
II.B.2.a	The owner/operator shall load the railcars and storage tanks on-site by the use of bottom filling or a submerged fill pipe. [R307-401-8]
II.B.2.b	The owner/operator shall keep the storage tank thief hatches and other tank openings closed and sealed except during tank unloading or other maintenance activities. [R307-401-8]
II.B.2.c	The owner/operator shall conduct visual inspections of each internal floating roof storage tank according to the methods and procedures specified in 40 CFR 60.113b(a). [40 CFR 60 Subpart Kb]
II.B.2.c.1	The owner/operator shall keep and maintain records of initial visual inspections of each internal floating roof storage tank for the life of the equipment. [40 CFR 60 Subpart Kb]
II.B.3	**Flare Requirements**
II.B.3.a	The owner/operator shall not allow any visible emissions from the flare. [R307-401-8]
II.B.3.a.1	Visual determination of smoke emissions from flares shall be conducted according to 40 CFR 60, Appendix A, Method 22. [R307-401-8]
II.B.3.b	The flare shall operate with a continuous pilot flame and be equipped with an auto-igniter. [R307-401-8]
II.B.3.c	The owner/operator shall install a flare that is certified to meet a VOC control efficiency of no less than 98%. [R307-401-8]
II.B.3.c.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of the manufacturer's emissions guarantee for the installed flare. [R307-401-8]
II.B.4	**Fugitive Dust Requirements**
II.B.4.a	The owner/operator shall not allow visible emissions from haul roads, terminal access roads, and mobile equipment in operational areas to exceed 20% opacity. [R307-205]
II.B.4.a.1	Visible emission determinations for fugitive dust from haul-road traffic and mobile equipment areas shall use procedures similar to Method 9. The normal requirement for observations to be made at 15-second intervals over a six-minute period, however, shall not apply. Visible emissions shall be measured at the densest point of the plume but at a point not less than 1/2 vehicle length behind the vehicle and not less than 1/2 the height of the vehicle. [R307-205]
II.B.4.b	The owner/operator shall pave all haul roads associated with the Price River Oil Transloading Facility. [R307-401-8]
II.B.4.c	The owner/operator shall vacuum sweep and flush with water all the paved haul roads on site to maintain the opacity limit listed in this AO. The owner/operator shall use an operational vacuum sweeper and water truck to conduct the required vacuum sweeping and watering. The owner/operator may stop flushing the paved haul roads with water when the temperature is below freezing but shall apply other controls as necessary to prevent visible emissions from exceeding the opacity limits listed in this AO. The owner/operator may stop vacuum sweeping the paved haul roads when the haul roads are covered with snow or ice. [R307-401-8]

II.B.4.c.1	Records of vacuum sweeping and water application shall be kept for all periods when the plant is in operation. The records shall include the following items: A. Date and time vacuum sweeping and water application were made B. Number of vacuum sweeping and water application made and quantity of water applied C. Rainfall amount received, if any D. Records of temperature, if the temperature was below freezing E. Records of any other control used to reduce fugitive dust. [R307-401-8]
II.B.5	**Monitoring Requirements of Fugitive Emissions (Leak Detection and Repair)**
II.B.5.a	The owner/operator shall develop a fugitive emissions monitoring plan for the storage tanks and flare operations. At a minimum, the plan shall include: A. Monitoring frequency B. Monitoring technique and equipment C. Procedures and timeframes for identifying and repairing leaks D. Recordkeeping practices E. Calibration and maintenance procedures. [R307-401-8]
II.B.5.b	The owner/operator shall conduct monitoring surveys on-site to observe each "fugitive emissions component" for "fugitive emissions." A. "Fugitive emissions component" means any component that has the potential to emit fugitive emissions of VOC, including but not limited to valves, connectors, pressure relief devices, open-ended lines, flanges, covers, and closed vent systems, thief hatches or other openings, instruments, and meters B. "Fugitive emissions" are considered any visible emissions observed using optical gas imaging or a Method 21 instrument reading of 500 ppm or greater. [R307-401-8]
II.B.5.b.1	Monitoring surveys shall be conducted according to the following schedule: A. No later than 90 days after startup or 180 days from the date of this AO B. Annually after the initial leak detection inspection. [R307-401-8]

II.B.5.b.2	Monitoring surveys shall be conducted using one or both of the following to detect fugitive emissions: A. Optical gas imaging (OGI) equipment. OGI equipment shall be capable of imaging gases in the spectral range for the compound of highest concentration in the potential fugitive emissions. B. Monitoring equipment that meets U.S. EPA Method 21, 40 CFR Part 60, Appendix A. [R307-401-8]
II.B.5.c	If fugitive emissions are detected at any time, the owner/operator shall repair the fugitive emissions component as soon as possible but no later than 15 calendar days after detection. If the repair or replacement is technically infeasible, or would be unsafe to repair during operation of the unit, the repair or replacement must be completed during the next shutdown, or within 24 months, whichever is earlier. [R307-401-8]
II.B.5.c.1	The owner/operator shall resurvey the repaired or replaced fugitive emissions component no later than 30 calendar days after the fugitive emissions component was repaired. [R307-401-8]
II.B.5.d	The owner/operator shall maintain records of the fugitive emissions monitoring plan, monitoring surveys, repairs, and resurveys. [R307-401-8]

PERMIT HISTORY

This Approval Order shall supersede (if a modification) or will be based on the following documents:

Supersedes	AO DAQE-AN148620003-20 dated October 21, 2020
Is Derived From	NOI dated September 26, 2023
Incorporates	Additional Information dated November 27, 2023
Incorporates	Additional Information dated May 1, 2024
Incorporates	Additional Information dated August 14, 2024
Incorporates	Additional Information dated August 28, 2024
Incorporates	Additional Information dated October 18, 2024
Incorporates	Additional Information dated October 30, 2024

ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by Environmental Protection Agency to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - Title 40 of the Code of Federal Regulations Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ/UDAQ	Division of Air Quality
DAQE	This is a document tracking code for internal Division of Air Quality use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - Title 40 of the Code of Federal Regulations 52.21 (b)(49)(i)
GWP	Global Warming Potential - Title 40 of the Code of Federal Regulations Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/YR	Pounds per year
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
VOC	Volatile organic compounds

EXHIBIT 24

Savage Wellington Transload Terminal to Provide Utah Crude-by-Rail Connection, Unlock Economic Growth Opportunities for Producers and Refiners

January 08, 2025 10:15 ET | Source: Savage

Follow

SALT LAKE CITY, Jan. 08, 2025 (GLOBE NEWSWIRE) -- Savage today announced plans to develop a new crude-by-rail transload terminal to connect supply chains for transporting Uinta Basin crude oil from wellheads to refinery markets across North America. The new terminal, located near Wellington in Carbon County, Utah, will unload Uinta Basin yellow and black wax crude from tanker trucks into two heated tanks. The crude will then be loaded into unit trains of insulated rail cars, via two rail loops, for delivery to end-market destinations.

"Utah has a long history of contributing to the U.S. energy supply, and this new transload terminal will build on that legacy," said Gov. Spencer Cox. "By unleashing Utah's energy to markets across North America, this project not only strengthens our state's economy but also enhances energy security for the entire nation. This is a win for our producers, our rural communities, and America's energy independence."

"Developing a new Savage transload terminal in Wellington will allow Uinta Basin producers to increase their production and access new markets without the logistical challenges of long-haul trucking or waiting on other logistical solutions requiring long lead times," said Jason Ray, president of Savage Infrastructure. "We believe this transload terminal will be the most efficient and cost-advantaged terminal in the area for producers and also for refineries seeking Uinta Basin crude."

The Savage Wellington Transload Terminal is strategically located with connections to both Union Pacific and BNSF railroads, which will provide customers with access to the national rail network and every refinery center in the United States.

"We're excited to develop this new market solution," said Phillip Hoskins, vice president, business development at Savage. "We've completed the purchase of 277 acres of land zoned for heavy industrial use and obtained necessary permits to start operations. The terminal engineering and design have been completed and we are working closely with the railroads to obtain final design approval."

The Wellington terminal is part of the growing Savage Transload Network of over 50 transload terminals across North America, and will also be capable of handling other industrial bulk and liquid commodities to support regional growth. Located about a half mile north of the Savage Energy Terminal in Price, UT, the new Wellington terminal will be developed within the Utah Inland Port Authority's Castle Country Project Area, supporting the state's objectives for growing strategic infrastructure, enhancing energy access, expanding growth in rural communities and driving sustainable development in Carbon and Emery Counties.

"The Port is proud to support Savage as they develop this new facility within the boundaries of our Castle Country Project Area," said Ben Hart, executive director of the Utah Inland Port Authority. "Projects like this are critical to elevating Utah's logistics system and spurring rural economic growth."

"We remain bullish about the growth of the Uinta Basin, and one of the keys to this growth is the export market," said Rikki Hrenko-Browning, president of Utah Petroleum Association. "We're proud to have Savage as members, and this project is one of many infrastructure investments we hope to welcome as we look toward the future of the Uinta Basin."

To discuss business opportunities, please contact our Business Development team.

About Savage

Established in 1946, Savage is a privately held, global provider of supply chain infrastructure and solutions, with more than 4,000 Team Members in about 200 locations across the United States, Canada, Mexico and

Company Profile

Savage

Website:
https://www.savageservices.com/

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Attachments

- Savage Wellington Transload Terminal
- Savage crude-by-rail operations



Savage Wellington Transload Terminal

Savage is developing a new crude-by-rail transload terminal near Wellington, in Carbon County, Utah



Savage crude-by-rail operations

Savage team members providing crude-by-rail services at a company facility in North Dakota

Tags

crude oil | crude-by-rail | transload | supply chain | Uinta Basin

Related Links

- Savage website
- Savage Transload Network

Contact Data

Jeff Hymas
Savage
801-944-6584
jeffhymas@savageco.com

Contact

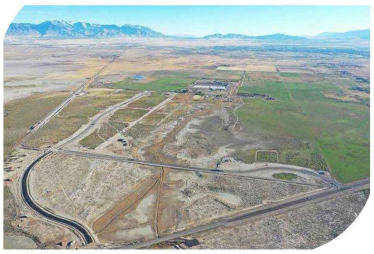
Recommended Reading

October 30, 2025 10:56 ET | Source: Savage

Interstate Business Park to connect to Savage Tooele Railroad

GRANTSVILLE, UT, Oct. 30, 2025 (GLOBE NEWSWIRE) -- Savage announced today that Interstate Business Park will be connecting to the Savage Tooele Railroad – a new short-line railroad that celebrated...

Read More



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EXHIBIT 25

State of Utah

SPENCER J. COX
Governor

DEIDRE HENDERSON
Lieutenant Governor

Department of
Environmental Quality

Tim Davis
Executive Director

DIVISION OF AIR QUALITY
Bryce C. Bird
Director

DAQE-AN161780002-25

October 2, 2025

William Kaiser
Savage Infrastructure LLC
901 West Legacy Center Way
Midvale, UT 84047
WilliamKaiser@Savageco.com

Dear Mr. Kaiser:

Re: Approval Order: Modification to Approval Order DAQE-AN161780001-24 to Increase Crude Oil Transloading Limits and Add Equipment
Project Number: N161780002

The attached Approval Order (AO) is issued pursuant to the Notice of Intent (NOI) received on January 15, 2025. Savage Infrastructure LLC must comply with the requirements of this AO, all applicable state requirements (R307), and Federal Standards.

The project engineer for this action is **Lucia Mason**, who can be contacted at (385) 707-7669 or lbmason@utah.gov. Future correspondence on this AO should include the engineer's name as well as the DAQE number shown on the upper right-hand corner of this letter. Comments were received and considered on this action.

Sincerely,

Bryce C. Bird
Director

BCB:LM:jg

cc: Southeastern Utah District Health Department

STATE OF UTAH
Department of Environmental Quality
Division of Air Quality

APPROVAL ORDER
DAQE-AN161780002-25
Modification to Approval Order DAQE-AN161780001-24 to Increase Crude Oil Transloading Limits and Add Equipment

Prepared By
Lucia Mason, Engineer
(385) 707-7669
lbmason@utah.gov

Issued to
Savage Infrastructure LLC - Wellington Crude Transloading Facility

Issued On
October 2, 2025

Issued By



Bryce C. Bird
Director
Division of Air Quality

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GENERAL INFORMATION

CONTACT/LOCATION INFORMATION

Owner Name
Savage Infrastructure LLC

Source Name
Savage Infrastructure LLC - Wellington Crude Transloading Facility

Mailing Address
901 West Legacy Center Way
Midvale, UT 84047

Physical Address
Remote 2 Miles West of Wellington
Carbon County, UT

Source Contact
Name: William Kaiser
Phone: (801) 424-7272
Email: WilliamKaiser@Savageco.com

UTM Coordinates
519,386 m Easting
4,377,987 m Northing
Datum NAD83
UTM Zone 12

SIC code 5171 (Petroleum Bulk Stations & Terminals)

SOURCE INFORMATION

General Description
Savage Infrastructure LLC (Savage) transloads heavy crude oil from tanker trucks to railcars in Carbon County. The heavy crude oil is first transferred from tanker trucks to three (3) internal floating roof (IFR) storage tanks using fifteen (15) loading spots. The crude oil then is transferred from the IFR storage tanks to railcars. Emissions from railcar loading are captured by a vapor combustion unit. Two (2) propane-fired, 14.3 MMBtu/hr boilers heat the heavy crude oil for transfer and hold the IFR storage tanks at a constant temperature of 150 degrees Fahrenheit. One (1) 1,320 hp Tier 2 diesel-fired emergency generator engine is located at the facility. The facility transfers up to 29,200,000 barrels (1 barrel = 42 gallons) of heavy crude oil per year.

NSR Classification
Minor Modification at Minor Source

Source Classification
Located in Attainment Area
Carbon County
Airs Source Size: B

Applicable Federal Standards
NSPS (Part 60), A: General Provisions
NSPS (Part 60), Dc: Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units
NSPS (Part 60), Kc: Standards of Performance for Volatile Organic Liquid Storage Vessels

Project Description
Savage has requested the following changes to its AO:

1) Reconfigure transloading operations. Oil will be loaded from tanker trucks into IFR crude oil storage tanks and then from the IFR storage tanks into railcars. Emissions from the railcar loading will be controlled by a vapor combustion unit. Previously, the facility loaded crude oil directly from tanker trucks into railcars and controlled emissions using a vapor balance system. Three (3) IFR storage tanks and one (1) vapor combustion unit will be installed onsite.

2) Increase site-wide crude oil transloading throughput from 10.95 million to 29.20 million barrels of crude oil per year.

3) Add one (1) 1,320 hp emergency diesel-fired generator engine.

4) Pave all haul roads and decrease the total haul road lengths to 2,034 ft.

SUMMARY OF EMISSIONS

The emissions listed below are an estimate of the total potential emissions from the source. Some rounding of emissions is possible.

Criteria Pollutant	Change (TPY)	Total (TPY)
CO_2 Equivalent	5715.56	22761.56
Carbon Monoxide	8.33	18.85
Nitrogen Oxides	9.07	10.95
Particulate Matter - PM_{10}	-11.83	6.03
Particulate Matter - $PM_{2.5}$	0.09	2.73
Sulfur Dioxide	0.02	0.10
Volatile Organic Compounds	17.27	24.28

Hazardous Air Pollutant	Change (lbs/yr)	Total (lbs/yr)
Benzene (Including Benzene From Gasoline) (CAS #71432)	97	137
Formaldehyde (CAS #50000)	-1	19
Generic HAPs (CAS #GHAPS)	2	2
Hexane (CAS #110543)	2369	3669
Naphthalene (CAS #91203)	1	1
Toluene (CAS #108883)	26	46
	Change (TPY)	**Total (TPY)**
Total HAPs	1.25	1.94

SECTION I: GENERAL PROVISIONS

I.1	All definitions, terms, abbreviations, and references used in this AO conform to those used in the UAC R307 and 40 CFR. Unless noted otherwise, references cited in these AO conditions refer to those rules. [R307-101]
I.2	The limits set forth in this AO shall not be exceeded without prior approval. [R307-401]
I.3	Modifications to the equipment or processes approved by this AO that could affect the emissions covered by this AO must be reviewed and approved. [R307-401-1]
I.4	All records referenced in this AO or in other applicable rules, which are required to be kept by the owner/operator, shall be made available to the Director or Director's representative upon request, and the records shall include the two-year period prior to the date of the request. Unless otherwise specified in this AO or in other applicable state and federal rules, records shall be kept for a minimum of two (2) years. [R307-401-8]
I.5	At all times, including periods of startup, shutdown, and malfunction, owners and operators shall, to the extent practicable, maintain and operate any equipment approved under this AO, including associated air pollution control equipment, in a manner consistent with good air pollution control practice for minimizing emissions. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to the Director which may include, but is not limited to, monitoring results, opacity observations, review of operating and maintenance procedures, and inspection of the source. All maintenance performed on equipment authorized by this AO shall be recorded. [R307-401-4]
I.6	The owner/operator shall comply with UAC R307-107. General Requirements: Breakdowns. [R307-107]
I.7	The owner/operator shall comply with UAC R307-150 Series. Emission Inventories. [R307-150]
I.8	The owner/operator shall submit documentation of the status of construction or modification to the Director within 18 months from the date of this AO. This AO may become invalid if construction is not commenced within 18 months from the date of this AO or if construction is discontinued for 18 months or more. To ensure proper credit when notifying the Director, send the documentation to the Director, attn.: NSR Section. [R307-401-18]

SECTION II: PERMITTED EQUIPMENT

II.A THE APPROVED EQUIPMENT

II.A.1	**Wellington Crude Transloading Facility**

II.A.2	**Three (3) IFR Tanks** Contents: Heavy Crude Oil **Two (2) IFR Storage Tanks:** Capacity: 99,000 barrels **One (1) IFR Storage Tank:** Capacity: 137,000 barrels NSPS Applicability: 40 CFR 60 Subpart Kc
II.A.3	**One (1) Vapor Combustion Unit** VOC Control Device (99% VOC destruction efficiency, 99% annual run time availability) Stack Height: 247", Stack Outer Diameter: 93.12" Design Flow Rate: 650 mscf/d at 1 psig
II.A.4	**Two (2) Boilers** Rating: 14.3 MMBtu/hr, each Fuel: Propane or Natural Gas NSPS Applicability: 40 CFR 60 Subpart Dc
II.A.5	**Two (2) Pressurized Fuel Storage Tanks** Fuel: Liquid Propane Capacity: 60,000 gallons each
II.A.6	**One (1) Emergency Generator Engine** Rating: 1,320 hp Fuel: Diesel EPA Certification: Tier 2 NSPS Applicability: 40 CFR 60 Subpart IIII MACT Applicability: 40 CFR 63 Subpart ZZZZ

SECTION II: SPECIAL PROVISIONS

II.B REQUIREMENTS AND LIMITATIONS

II.B.1	**Site-Wide Requirements**
II.B.1.a	The owner/operator shall not transload more than 29,200,000 barrels (1 barrel = 42 gallons) of crude oil per rolling 12-month period. [R307-401-8]

II.B.1.a.1	To determine compliance with the above throughput limit, the owner/operator shall: A. Determine the crude oil throughput with process flow meters and/or sales records B. Record crude oil throughput on a daily basis C. Use the monthly throughput data to calculate a new 12-month total by the 20th day of each month using data from the previous 12 months D. Keep the throughput records for all periods the plant is in operation. [R307-401-8]
II.B.1.b	Unless otherwise specified in this AO, the owner/operator shall not allow visible emissions to exceed 10% opacity. [R307-401-8]
II.B.1.b.1	Unless otherwise specified in this AO, opacity observations of emissions from stationary sources shall be conducted in accordance with 40 CFR 60, Method 9. [R307-401-8]
II.B.2	**Crude Oil Loading and Storage Requirements**
II.B.2.a	The owner/operator shall install crude oil storage tanks that meet the requirements in 40 CFR 60.112c(b) regarding IFR tanks. 40 CFR 60 Subpart Kc. [R307-401-8]
II.B.2.b	To monitor and maintain the IFR tanks, the owner/operator shall: A. Inspect each IFR tank according to 40 CFR 60.113c(a)(2)(i) at least once every 12 calendar months after the initial fill B. Inspect each IFR tank according to 40 CFR 60.113c(a)(2)(ii) each time the storage vessel is emptied and degassed or at a frequency no greater than every 120 calendar months, whichever occurs first. [40 CFR 60 Subpart Kc. R307-401-8]
II.B.2.b.1	To demonstrate compliance with the above IFR tank monitoring and maintenance requirements, the owner/operator shall keep the following records: A. The date of each inspection B. The type of inspection conducted C. Any malfunctions detected and corrective action taken. [40 CFR Subpart Kc, R307-401-8]
II.B.2.c	The owner/operator shall: A. Only load the crude oil to the IFR storage tanks directly from the tanker trucks B. Only load the crude oil to the railcars directly from the IFR storage tanks C. Only load crude oil as described in A and B through submerged or bottom loading. [R307-401-8]

II.B.2.d	The owner/operator shall only transload the crude oil from tanker trucks into railcars that are certified for the NSPS level annual leak test. [R307-401-8]
II.B.2.d.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of annual leak test certifications. [R307-401-8]
II.B.2.e	The owner/operator shall conduct monthly audio, visual, and olfactory (AVO) inspections of the crude oil piping system for dripping liquids. [R307-401-8]
II.B.2.e.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records containing the following information: A. Date of inspection B. Any leaks detected and associated corrective action. [R307-401-8]
II.B.3	**Vapor Combustion Unit Requirements**
II.B.3.a	The owner/operator shall route all emissions from loading crude oil from IFR storage tanks into railcars through the vapor combustion unit. [R307-401-8]
II.B.3.b	The owner/operator shall not allow any visible emissions from the vapor combustion unit. [R307-401-8]
II.B.3.b.1	Opacity observations on the vapor combustion unit shall be conducted in accordance with 40 CFR 60, Method 22. [R307-401-8]
II.B.3.c	The owner/operator shall install a vapor combustion unit that is certified to meet a VOC destruction efficiency of no less than 99% and an annual run time availability of no less than 99%. [R307-401-8]
II.B.3.c.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of the manufacturer's emissions guarantee. [R307-401-8]
II.B.3.d	The owner/operator shall operate the vapor combustion unit according to manufacturer’s instructions. [R307-401-8]
II.B.3.d.1	To demonstrate compliance with the above condition, the owner/operator shall maintain records of the manufacturer's operating recommendations. [R307-401-8]
II.B.4	**Haul Road Requirements**
II.B.4.a	The owner/operator shall not exceed 2,034 ft of paved haul roads. [R307-401-8]
II.B.4.a.1	To determine compliance with the above length limit, the owner/operator shall measure and record the paved haul road length at least once every twelve (12) months. The owner/operator shall determine lengths using Global Positioning System (GPS) measurements or aerial photographs. The owner/operator shall include the date each length measurement was taken in their records. [R307-401-8]
II.B.4.b	The owner/operator shall not allow visible emissions from haul roads and fugitive dust sources on site to exceed 20% opacity. [R307-401-8]

II.B.4.b.1	Opacity observations of fugitive dust from intermittent sources shall be conducted according to 40 CFR 60, Appendix A, Method 9; however, the requirement for observations to be made at 15-second intervals over a six-minute period shall not apply. The number of observations and the time period shall be determined by the length of the intermittent source. For fugitive dust generated by mobile sources, visible emissions shall be measured at the densest point of the plume but at a point not less than one-half vehicle length behind the vehicle and not less than one-half the height of the vehicle. [R307-401-8]
II.B.4.c	The owner/operator shall sweep and flush all paved haul roads with water to maintain the opacity limits listed in this AO. If the temperature is below freezing, the owner/operator shall continue to sweep the paved roads but may stop flushing the pavement water until the temperature returns to above freezing. If the haul roads are covered with snow or ice, the owner/operator may stop sweeping the paved haul roads until the paved roads are cleared of snow and ice. [R307-401-8]
II.B.4.c.1	The owner/operator shall keep records of sweeping and water application to paved haul roads for all periods when the plant is in operation. Records shall include the following items regarding paved haul roads: A. Date and time treatments were made B. Number of treatments made, and quantity of water applied C. Rainfall amount received, if any D. The temperature, if the temperature is below freezing E. Road conditions, if the paved haul roads are covered with snow or ice. [R307-401-8]
II.B.5	**Emergency Generator Engine Requirements**
II.B.5.a	The owner/operator shall install an emergency generator engine that is certified to meet the following emission rates: NMHC + NO_x: 4.8 g/hp-hr CO: 2.6 g/hp-hr PM: 0.15 g/hp-hr [R307-401-8]
II.B.5.a.1	To demonstrate compliance with the above emission rates, the owner/operator shall keep a record of the manufacturer's certification of the emission rates. The record shall be kept for the life of the equipment. [R307-401-8]
II.B.5.b	The owner/operator shall not operate the emergency generator engine on-site for more than 100 hours per calendar year during non-emergency situations. There is no time limit on the use of the engine during emergencies. [40 CFR 60 Subpart IIII, 40 CFR 63 Subpart ZZZZ, R307-401-8]

II.B.5.b.1	To determine compliance with a rolling 12-month total, the owner/operator shall calculate a new 12-month total by the 20th day of each month using data from the previous 12 months. Records documenting the operation of the emergency engine shall be kept in a log and shall include the following: A. The date the emergency engine was used B. The duration of operation in hours C. The reason for the emergency usage. [R307-401-8]
II.B.5.b.2	To determine the duration of operation, the owner/operator shall install a non-resettable hour meter for the emergency engine. [40 CFR 63 Subpart ZZZZ, R307-401-8]
II.B.5.c	The owner/operator shall not operate the emergency generator engine for non-emergency purposes before 6:00 AM or after 6:00 PM. [R307-410-4]
II.B.5.c.1	To determine compliance with the above operational limits, the owner/operator shall keep the records listed below for each time the emergency generator engine is used for non-emergency purposes: A. The date B. The time generator engine use started C. The time generator engine use stopped. [R307-401-8]
II.B.5.d	The owner/operator shall only use diesel fuel (e.g., fuel oil #1, #2, or diesel fuel oil additives) as fuel in the emergency generator engine. [R307-401-8]
II.B.5.e	The owner/operator shall only combust diesel fuel that meets the definition of ultra-low sulfur diesel (ULSD), which has a sulfur content of 15 ppm or less. [40 CFR 60 Subpart IIII, 40 CFR 63 Subpart ZZZZ]
II.B.5.e.1	To demonstrate compliance with the ULSD fuel requirement, the owner/operator shall maintain records of diesel fuel purchase invoices or obtain certification of sulfur content from the diesel fuel supplier. The diesel fuel purchase invoices shall indicate that the diesel fuel meets the ULSD requirements. [R307-401-8]
II.B.6	**Boiler Requirements**
II.B.6.a	The owner/operator shall use only propane and/or natural gas as fuel in the boilers. [R307-401-8]
II.B.6.b	The owner/operator shall install boilers that each have an ultra-low NO_x burner certified by the manufacturer to emit less than 9 ppm NO_x. [R307-401-8]
II.B.6.b.1	The owner/operator shall keep the manufacturer certification for the ultra-low NO_x burners on site as long as the boilers are in operation. [R307-401-8]

PERMIT HISTORY

This Approval Order shall supersede (if a modification) or will be based on the following documents:

Supersedes	AO DAQE-AN161780001-24 dated June 26, 2024
Is Derived From	NOI dated January 15, 2025
Incorporates	Additional Information dated March 2, 2025
Incorporates	Additional Information dated May 5, 2025

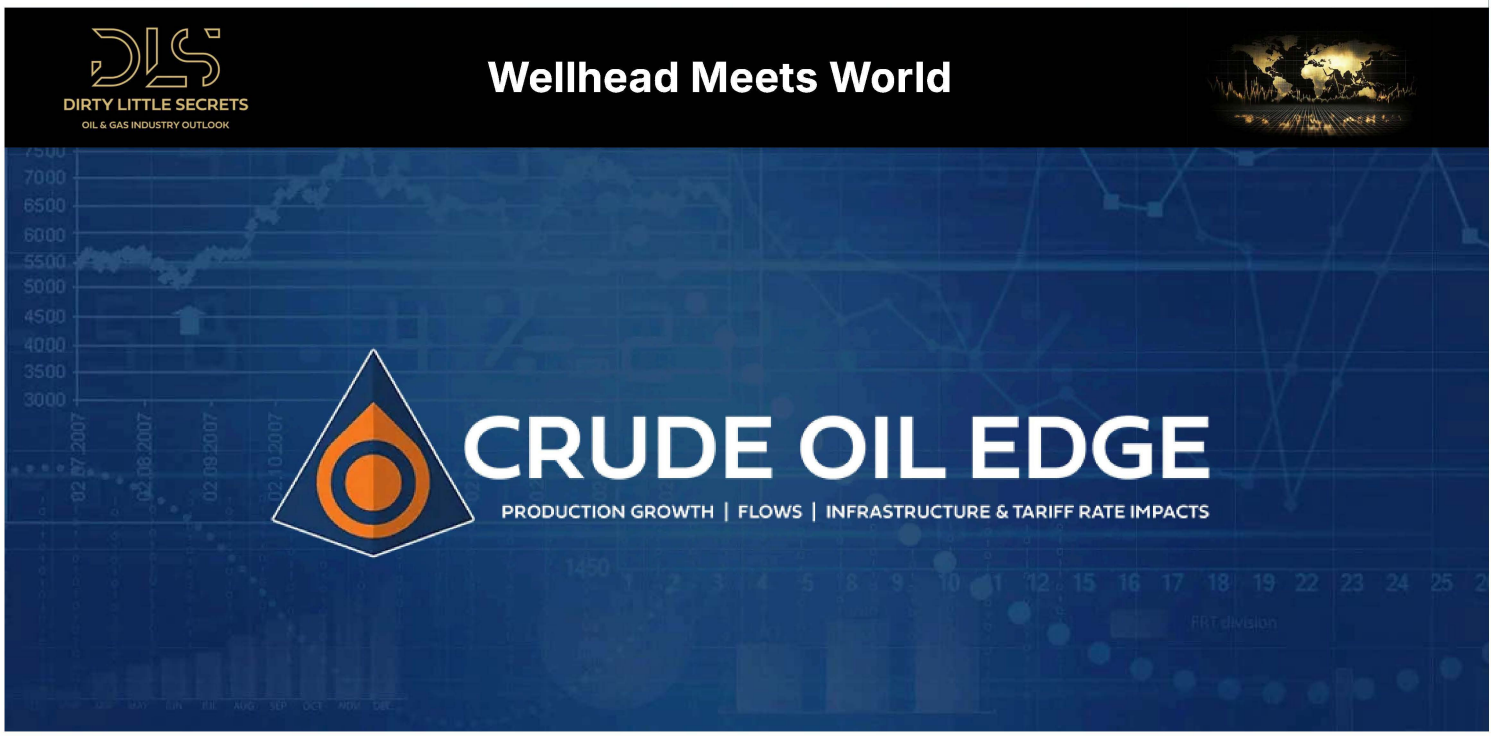
ACRONYMS

The following lists commonly used acronyms and associated translations as they apply to this document:

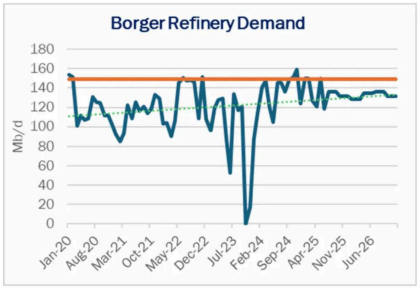
40 CFR	Title 40 of the Code of Federal Regulations
AO	Approval Order
BACT	Best Available Control Technology
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CDS	Classification Data System (used by Environmental Protection Agency to classify sources by size/type)
CEM	Continuous emissions monitor
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CMS	Continuous monitoring system
CO	Carbon monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent - Title 40 of the Code of Federal Regulations Part 98, Subpart A, Table A-1
COM	Continuous opacity monitor
DAQ/UDAQ	Division of Air Quality
DAQE	This is a document tracking code for internal Division of Air Quality use
EPA	Environmental Protection Agency
FDCP	Fugitive dust control plan
GHG	Greenhouse Gas(es) - Title 40 of the Code of Federal Regulations 52.21 (b)(49)(i)
GWP	Global Warming Potential - Title 40 of the Code of Federal Regulations Part 86.1818-12(a)
HAP or HAPs	Hazardous air pollutant(s)
ITA	Intent to Approve
LB/YR	Pounds per year
MACT	Maximum Achievable Control Technology
MMBTU	Million British Thermal Units
NAA	Nonattainment Area
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
R307	Rules Series 307
R307-401	Rules Series 307 - Section 401
SO_2	Sulfur dioxide
Title IV	Title IV of the Clean Air Act
Title V	Title V of the Clean Air Act
TPY	Tons per year
UAC	Utah Administrative Code
VOC	Volatile organic compounds

EXHIBIT 26

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29 OCT 2025

ET, FOURPOINT TO EXPAND UINTA CRUDE TERMINAL

Bakken, Crude, Crude Oil Edge, Eagle Ford, Permian

Posted by: Julian Renton

Executive Summary:

Rigs: The total US rig count decreased during the week of Oct. 12 to 516.

Infrastructure: FourPoint Resources has reached an agreement with Energy Transfer (ET) to double the size of the Price River Terminal in Wellington, UT as competition heats up to move crude oil from the Uinta Basin.

Supply & Demand: The US natural gas pipeline sample, a proxy for change in oil production, increased 0.3% W-o-W across all liquids-focused basins.

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- DJ (+1): Chevron
- Eagle Ford (+1): Pursuit Oil & Gas

Infrastructure:

FourPoint Resources has reached an agreement with Energy Transfer (ET) to double the size of the Price River Terminal in Wellington, UT as competition heats up to move crude oil from the Uinta Basin.

Under the agreement announced Oct. 9, the partners will build a continuous loop track to improve rail logistics, plus a railcar rack capable of loading 140 Mb/d of crude oil. The project will add nine new rail loading arms, four new truck offload lanes, and construct a heated storage tank with 140 Mbbl of capacity. The companies expect to complete the expansion by 4Q26.

BASINS	W-o-W Rig Chg	Avg Rig Count				
		Sep 28	Sep 21	Sep 14	Sep 7	Aug 31
Liquids-Driven Basins						
Anadarko	1	52	51	53	53	53
Bakken	0	32	32	32	31	31
DJ	0	9	9	11	10	10
Eagle Ford	0	49	49	48	45	44
Permian	(3)	245	249	250	252	253
Delaware	(2)	141	143	145	148	147
Midland	(1)	105	106	105	104	106
Powder River	0	7	7	7	7	9
Uinta	1	11	10	9	9	9
Liquids - TOTAL RIGS	(1)	406	407	410	408	409
Gas Basins						
ArkLaTex	0	52	52	52	52	52
Barnett	1	3	2	2	2	3
Marcellus + Utica	(2)	35	37	38	36	34
Gas - TOTAL RIGS	(1)	90	91	92	90	89
Other	3	33	30	30	29	32
Total US Rigs	2	530	528	531	527	529

ET owns 55% of the Price River Terminal, located southeast of Salt Lake City on the western edge of the Uinta. Under the agreement, FourPoint will take 50 Mb/d of capacity in the expanded terminal. The Denver-based producer has steadily run 1-2 rigs in the Uinta since 4Q24, according to the "Producer to System Analysis" dashboard in ***Energy Data Studio***.

The Price River project will compete directly with Wildcat Midstream's expansion of the Wildcat Terminal near Helper, UT. Wildcat, northwest of Price River Terminal, plans to install additional unloading bays, upgrade loading systems and build a dedicated tank farm. The project will increase loading capacity from 20 to 100 Mb/d just next door.

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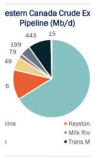
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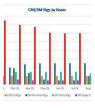
Sinclair Proposes Rockies Route to Fill Western Products Shortfall

December 10, 2025



Enbridge Advances Mainline Expansion as Canadian Exports Fill System

December 3, 2025



SM Energy-Civitas Merger Creates Top 10 US Oil Producer

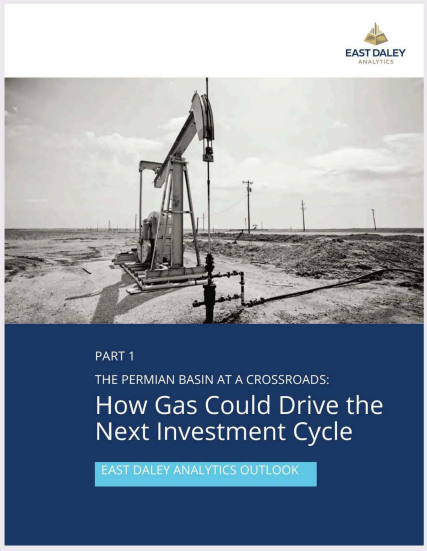
November 19, 2025

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Since 2020, Uinta production has been on the rise, averaging ~276 Mb/d in 2Q25. East Daley's Production Scenario Tool (PST) in ***Energy Data Studio*** projects 3.2% Y-o-Y production growth in 2026. The basin in northeastern Utah has longstanding takeaway constraints, limiting demand to local refineries near Salt Lake City and some railing capacity. Expansions like the Price River and Wildcat projects are critical to enable future growth from the basin.

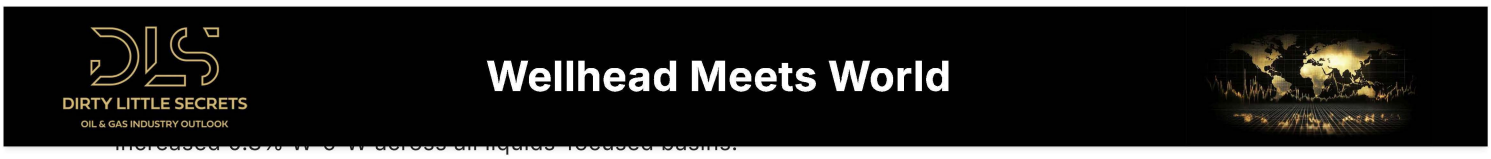
Along with the terminal expansion, FourPoint announced a rebranding of the Uinta's unique crude oil. Going forward, FourPoint will market the crude as "American Premium Uinta (APU)," changing the name from Uinta Wax. Uinta crude has some of the highest paraffinic content among US crude oil streams, but is also low in impurities like sulfur and metals.



The Permian Basin at a Crossroads: Download the Latest White Paper

The Permian Basin is the heart of the US energy industry, supplying half of crude oil and NGL production and nearly 20% of natural gas. Yet market pressures are forcing changes, prompting billions in new pipeline investments and reorienting how operators approach the storied basin. East Daley's new white paper, *The Permian Basin at a Crossroads*, is the first of a 3-part series looking at the shifts underway in the Permian. In this series, we reveal how LNG demand and AI data centers could transform Permian gas into a primary revenue driver. We also review the multi-billion-dollar infrastructure needed to unlock this shift, and what's at stake for oil, gas and midstream operators.

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increased 0.3% W-o-W across all liquids-focused basins.

Gas Sample Proxy	Sep. 30 Avg (MMcf/d)	Oct. 7 Avg (MMcf/d)	W-o-W
Anadarko	4,193	4,201	0.2%
Arkoma	650	554	-14.7%
Barnett	853	873	2.4%
Gulf of America	2,529	2,554	1.0%
Permian	6,230	6,037	-3.1%
Rockies	8,810	8,771	-0.4%
Eagle Ford	1,694	1,659	-2.0%
Williston	2,537	2,468	-2.7%
Grand Total	**27,512**	**27,141**	**-1.3%**

The Anadarko, Williston and Barnett basins decreased by 1%, 4.3% and 18.3% respectively. These decreases coincided with increases in the rest of the basins. Samples rose across Texas. The Gulf of America sample increased 2.9%, the Permian increased 4.9% and the Eagle Ford increased 2.4% W-o-W. The Rockies and the Gulf of America have a high correlation between gas volumes and crude oil volumes, whereas the Permian and Eagle Ford basins correlation is less than 45%.

As of Oct. 23, there was ~1,800 Mb/d of refining capacity offline for planned maintenance. This week, additions to planned maintenance occurred with 430 Mb/d from BP's Whiting refinery and 120 Mb/d from ExxonMobil's Baton Rouge refinery.

Vessel traffic monitored by EDA along the Gulf Coast increased W-o-W. There were 24 vessels loaded for the week ending Oct. 25 following 21 the week prior.

Current Refinery Outages

Date: 10/13/2025	Operator	Event	Affected Capacity (Mb/d)	Start Date	End Date	Notes	City	State
Total Port Arthur Refinery	Total Petrochemicals & Refining USA	Planned Maintenance	151	8/22/2025	10/21/2025	ACU-1 CDU/ALKY/CAT Reformer/Coker Naphtha hydrotreater/ 3 distillate hydrotreaters	Port Arthur	TX
Marathon Catlettsburg Refinery	Marathon Petroleum	Planned Maintenance	139	9/26/2025	11/17/2025	Crude 5, condensate splitter, naphtha pre-treater, high pressure continuous catalytic reformer	Catlettsburg	KY
Marathon Catlettsburg Refinery	Marathon Petroleum	Planned Maintenance	35	9/26/2025	11/17/2025	Crude 5, condensate splitter, naphtha pre-treater, high pressure continuous catalytic reformer	Catlettsburg	KY
Valero Memphis Refinery	Valero Energy	Planned Maintenance	100	9/5/2025	11/5/2025	FCC, 105k E. CDU, CDU likely run no more than minimum rate of 36k b/d during work on FCC, new flare gas recovery system for North Flare	Memphis	TN
Marathon Garyville Refinery	Marathon Petroleum	Planned Maintenance	298	9/15/2025	10/27/2025	325k CDU 10A & B, 149k VDU shut 9/15	Garyville	LA
Marathon Galveston Bay Refinery	Marathon Petroleum	Planned Maintenance	67	9/20/2025	11/8/2025	67k CDU shut 9/15-16	Texas City	TX
Flint Hills Pine Bend Refinery	Flint Hills Resources	Planned Maintenance	150	9/9/2025	12/31/2025	170k CDU/85k VDU shut 9/9	Pine Bend	MN
Total Port Arthur Refinery	Total Petrochemicals & Refining USA	Planned Maintenance	150.857142857143	9/17/2025	12/8/2025	ACU-1 CDU/ALKY/CAT Reformer/Coker Naphtha hydrotreater/ 3 distillate hydrotreaters	Port Arthur	TX
Marathon Catlettsburg Refinery	Marathon Petroleum	Planned Maintenance	155	9/18/2025	12/14/2025	Crude 5, condensate splitter, naphtha pre-treater, high pressure continuous catalytic reformer	Catlettsburg	KY

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DOI: 10.1111/risa.14312

ORIGINAL ARTICLE

The relationship between freight train length and the risk of derailment

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Funding information
National Science Foundation, Directorate for Engineering, Grant/Award Number: 2051685

Abstract

In recent years, longer and heavier trains have become more common, primarily driven by efficiency and cost-saving measures in the railroad industry. Regulation of train length is currently under consideration in the United States at both the federal and state levels, because of concerns that longer trains may have a higher risk of derailment, but the relationship between train length and risk of derailment is not yet well understood. In this study, we use data on freight train accidents during the 2013–2022 period from the Federal Railroad Administration (FRA) Rail Equipment Accident and Highway-Rail Grade Crossing Accident databases to estimate the relationship between freight train length and the risk of derailment. We determine that longer trains do have a greater risk of derailment. Based on our analysis, running 100-car trains is associated with 1.11 (95% confidence interval: 1.10–1.12) times the derailment odds of running 50-car trains (or a 11% increase), even accounting for the fact that only half as many 100-car trains would need to run. For 200-car trains, the odds increase by 24% (odds ratio 1.24, 95% confidence interval: 1.20–1.28), again accounting for the need for fewer trains. Understanding derailment risk is an important component for evaluating the overall safety of the rail system and for the future development and regulation of freight rail transportation. Given the limitations of the current data on freight train length, this study provides an important step toward such an understanding.

KEYWORDS
derailment, freight train length, quasi-induced exposure, rail transportation, transportation safety

1 | INTRODUCTION

On February 3, 2023, 38 cars from a 151-car, 9300-ft-long freight train derailed in East Palestine, Ohio, leading to the release of hazardous materials that required the evacuation of more than 2000 residents. In response to this event and concerns that the length of the train may have contributed to the derailment, U.S. Senator Sherrod Brown introduced the Railway Safety Act of 2023, which, if enacted, would require the development of regulations regarding freight train length, among other things (Congress.gov, 2023). Additionally, several U.S. states are currently considering state-level regulations regarding freight train length (Bernton, 2023; CBS, 2023). The major freight rail industry association, the Association of American Railroads, expresses the industry's opposition to regulation of freight train length, arguing that "'Long trains' have operated safely for decades, and the industry's safety record has dramatically improved during that period" (AAR, 2023). However, general improvements in safety over time coinciding with increases in train length cannot be seen as evidence for a lack of association between the two. Moreover, identifying the relationship between freight train length and the risk of derailment is challenging and evidence with respect to this relationship is sparse in the current research literature. Although a number of related questions, such as how train length relates to the severity of a given derailment, have been examined in the literature, data availability challenges have made direct investigation of the relationship between train length and the likelihood of derailment difficult (Dick et al., 2021; Liu et al., 2017). Indeed, a 2019 U.S. Government Accountability Office report to Congress concludes that the safety implications of train length are poorly understood and that more study is needed to assess them (United States Government Accountability Office [US GAO], 2019).

The system-wide safety implications of utilizing longer freight trains are further complicated by the fact that when longer freight trains are used, fewer trains, on average, are

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needed to transport the same amount of freight. Thus, even if longer freight trains are at increased risk of derailment, that increased risk must be balanced against the benefits of using fewer freight trains in reducing overall exposure to derailment risk. Moreover, longer freight trains also have additional benefits for the U.S. rail transportation system, including improved system-wide fuel efficiency, lower system-wide emissions, and lower overall operating costs (United States Government Accountability Office [US GAO], 2019; Multer et al., 2022). Consequently, a better understanding of how freight train length impacts system-wide derailment risk can help policymakers and rail industry decision makers to better optimize freight train length policies and decisions (Ghofrani et al., 2022).

The major challenge to examining the relationship between freight train length and the risk of derailment is the lack of available exposure data. Although the length of trains involved in accidents is included in accident reports that railroads file with the Federal Railroad Administration (FRA), data on the lengths of trains that are not involved in accidents are largely unavailable. This lack of "exposure" data has precluded estimating the derailment risk by freight train length using traditional methods. In the work reported here, we overcome this lack of available exposure data for freight trains by applying the quasi-induced exposure (QIE) approach, a methodology designed to study risks in settings where exposure data are missing (Jiang et al., 2014; Keall & Newstead, 2009; Stamatiadis & Deacon, 1997). QIE compensates for the lack of true exposure data by employing data from a control group of accidents whose occurrence is unrelated to the factor of interest to proxy for exposure risk, creating "quasi-induced" exposure data (Jiang et al., 2014; Keall & Newstead, 2009). Using QIE, we analyze data on freight train accidents from the FRA Rail Equipment Accident (REA) and Highway-Rail Grade Crossing Accident (HRGCA) databases to estimate the relationship between freight train length and the risk of derailment.

2 | LITERATURE REVIEW

2.1 | Quasi-induced exposure (QIE)

QIE has been used extensively in studies of road traffic accidents because data on exposure by vehicle or driver characteristic is usually unavailable, whereas data on the characteristics of vehicles and drivers involved in accidents are accessible (Jiang et al., 2014; Keall & Newstead, 2009; Stamatiadis & Deacon, 1997). In practice, the QIE approach involves the creation of a combined sample containing both the accidents of interest as well as a set of control accidents whose occurrence is unrelated to the independent variable being analyzed. For example, Leslie et al. (2021) employed QIE to study, among several other questions, the effect of automobile lane departure warning (LDW) systems on the incidence of "lane departure" accidents by automobiles. These authors employed "rear-end struck" accidents, accidents in which a vehicle is rear-ended by a following vehicle as the control type of accidents, given that the likelihood of being rear-ended by another vehicle was assumed to be independent of the presence of LDW. These authors estimated the odds of a lane departure accident for LDW-equipped versus unequipped vehicles using a logistic regression analysis with a lane departure accident indicator as the dependent variable, an indicator of the presence of LDW on a vehicle as the key independent variable, and a set of controls for vehicle characteristics, driving conditions, and driver characteristics.

QIE analysis uses logistic regression with an indicator variable indicating whether a given event was of the accident type of interest (rather than the control accident type) as the dependent variable (Jiang et al., 2014; Keall & Newstead, 2009; Leslie et al., 2021; Stamatiadis & Deacon, 1997). Continuing the previous example, Leslie et al. (2021) conducted a logit regression analysis with an indicator that an accident is a "lane departure" accident (rather than a "rear-end struck" accident) as the dependent variable and the presence of a LDW system as the independent variable. Odds ratios estimated using this logistic regression approach are essentially equivalent to the raw odds ratios that could be obtained with proxy (quasi-induced) exposure data, but have the advantage that they may include control variables to account for variables other than the factor of interest that are known or suspected to affect the occurrence of the accident type of interest.

Although, to our knowledge, QIE has not previously been used to study rail accidents, we believe the approach is well suited to study freight train derailments so long as a control type of accident can be identified. The advantages are that train derailment risk as a function of train length can be systematically studied without obtaining train length data for the exposed population of trains (i.e., data that are not available), and this systematic study can include other factors that are known to impact train derailment risk to isolate the effects of train length. The disadvantage of this approach is that it requires the assumption that the control accident is independent of the factor of interest (i.e., train length), but we can demonstrate the impact of this assumption on the analysis results using simulated data (see Section 4.1).

2.2 | Derailment risk factors

Freight train derailment is an issue of significant interest to railroads, rail regulators, and communities because the impacts of a derailment can be substantial (Kaeeni et al., 2018; Li et al., 2018; Liu et al., 2017, Liu et al, 2012). Indeed, derailment is the most common type of serious train accident in the United States (Cao et al., 2020; Liu, 2016; Liu et al., 2017; Wang et al., 2020). Extant research examines several different risk factors for derailment. For example, a number of studies examine the effects of railroad track segment characteristics—such as traffic volume, track class, and method of operation—on risk of derailment (Anderson & Barkan, 2004; Liu et al., 2017; Nayak et al., 1983; Wang et al., 2020). This work has consistently found that derailment risk is lower for higher track classes, which is not

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surprising because higher track classes are required to be built to more stringent standards and maintained more carefully (Anderson & Barkan, 2004; Liu et al., 2017; Nayak et al., 1983). These studies also find that derailment risk is lower on track segments with higher traffic densities, due to more frequent inspection and maintenance of high-density track (Liu et al., 2017; Wang et al., 2020). Finally, this literature also finds that derailment risk is reduced on track segments where the method of operation is signaled relative to non-signaled segments (Liu et al., 2017).

Other literature has examined the relationship between characteristics of trains and the risk of derailment. For example, studies have examined the derailment risk of loaded relative to unloaded trains, finding significantly increased risk of derailment for loaded trains over unloaded ones (Li et al., 2018; Zhang et al., 2022). Additionally, Zhang et al. (2022) also studied the derailment risk of unit trains (trains composed of only one railcar type carrying only one type of freight) compared to mixed trains (trains with multiple railcar and freight types). They found that derailment risk per railcar-mile and per ton-mile of freight is lower for unit trains than for mixed trains.

2.3 | Exposure data in studies of derailment

As noted above, one of the biggest hurdles to studying the relationship between freight train length and derailment risk is lack of exposure data by train length. Traditional accident analysis methods would evaluate the impact of a factor (like train length) on the odds that a certain type of accident (such as derailment) occurs using data on both the number of accidents that occurred when the factor was and was not present and the number of non-accident occurrences (exposures) when the factor was and was not present. In the context of studying derailment, such exposure data would constitute the data on the number of trains of various lengths that did not derail.

Data on train length for trains involved in a derailment are available from the FRA—with length operationalized as the number of railcars making up the train, a common measure of freight train length (Multer et al., 2022; Zhang et al., 2022). However, data on how many safely completed, non-accident trips have been made by trains of different lengths (exposure data) are not readily available. Some have attempted to solve this challenge by employing high-level, nationwide exposure data. For example, Nayak et al. (1983) estimated the effect of track class on derailment risk using nationwide estimates of rail traffic flows by track class as exposure data. More recently, Liu et al. (2017) studied the effects of track class, method of operation, and rail traffic density on derailment risk using aggregate systemwide traffic data collected from each of the major U.S. railroads as exposure data. Although each of these extant approaches was well suited to the research question it was designed to address, none of them would allow us to address our question of interest because the available nationwide or systemwide data on non-accident rail trips are simply not broken down by train length. Because our analysis of interest requires exposure data by train length that does not exist, we required a different type of exposure data than any reported in the extant literature.

3 | DATA

3.1 | Derailment data

Freight train derailments in the United States are tracked by the FRA's REA database, which reports information filed by railroads that experience incidents or accidents that result in rail equipment and/or track damage above a certain threshold (currently $11,500). This information is reported to the FRA by involved railroads via form FRA F 6180.54. These REA reports contain information on several characteristics of the accident including but not limited to: accident type, accident date and time, accident location, reporting railroad, rail equipment type, visibility condition at the time of the accident, number of loaded and unloaded railcars, number of locomotives, and the number of railcars transporting hazardous materials. The FRA REA database is the primary source of information available on train derailments in the United States and has been used in virtually all prior work on derailments for U.S.-based railroads (Liu et al., 2017; Zhang et al., 2022).

To ensure that our analysis reflects only recent derailments, we extracted from the REA database information on all derailments occurring within the past 10 years (between 2013 and 2022), about 14,000 incidents. Given that our interest was in derailments of freight trains during normal freight transport (as many derailments occur in train yards and sidings outside of freight transport), we retained in the derailment sample only derailments whose "rail equipment type" is identified as "freight train" (rather than passenger train or other types of rail equipment) and that occurred on a mainline track (as opposed to a yard, siding, or industrial track). These restrictions follow those used in prior work on derailments (e.g., Liu et al., 2017). Our final REA derailment sample, after these restrictions, included 2906 derailments.

3.2 | Highway rail grade crossing incident data

QIE analysis requires a control type of accident that is unrelated to the independent variable of interest. Importantly, the QIE method does not require that the control accidents and the accidents of interest result from the same causes (Stamatiadis & Deacon, 1995). The primary requirement for effective control accidents is that their occurrence is independent of the explanatory variable of interest (Jiang et al., 2014). When this is the case, the incidence of control accidents in a location provides a reasonable approximation of a random sample of vehicles that transverse that location with respect to the explanatory variable being studied (Stamatiadis & Deacon, 1997). This quasi-random sample, then, may be used to represent the true exposure data (when it is not

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available). If the control accidents were not independent of the explanatory variable, their use to represent exposure data would bias the results of the analysis; if they were positively (negatively) correlated with the explanatory variable, their use would serve to artificially inflate (deflate) the prevenance of that variable in the exposure set. However, to the extent that the control accidents are unrelated to the explanatory variable, they can act as a quasi-random sample of exposure data in that location, whatever their causes.

As the control accident type in the analysis, we employ highway-rail grade-crossing incidents where the driver of a road vehicle attempted (unsuccessfully) to "beat the train" across the grade crossing. We chose this accident type as our control as it is unrelated to train length since road vehicle drivers at rail crossings would rarely have the sight perspective to judge train lengths greater than a few cars, making the accidents a direct result of the driver's actions and not train length (Oh et al., 2006). Due to long stopping distances, freight trains of any length would not be able to slow significantly before impact in this type of accident (Bentley & Bentley, 2007). Thus, the occurrence of this type of accident should be independent of train length and should serve well as a control accident type in a QIE analysis.

The data on highway-grade accidents used to build the sample of control accidents comes from the FRA HRGCA database. The HRGCA contains data on highway-rail grade-crossing incidents, which are incidents involving contact between trains and road vehicles or pedestrians at locations where roads and rail tracks cross at the same grade level. Involved railroads are required to report any contact between railroad equipment and highway users at a highway-rail grade crossing, no matter the severity of the incident, to the FRA (on form FRA F 6180.57). HRGCA reports contain much of the same information about involved rail equipment as the REA reports, including all of the characteristics mentioned above (with the exception that the HRGCA data include only an indicator for whether any railcar in a train contains hazardous materials rather than the number of cars transporting hazardous materials). HRGCA reports also contain information about the grade crossing where the incident occurred, the highway user involved in the incident, and damage to highway vehicles resulting from the incident. The HRGCA database is the main source of information about grade crossing accidents in the United States and is commonly used in research on these events (Liu et al., 2015; Lu & Tolliver, 2016).

For the initial HRGCA sample, we again extracted only grade crossing events occurring between 2013 and 2022, about 21,000 events. We also restricted the sample to include only events that occurred on a mainline track and that involved freight trains (rather than passenger trains or other types of rail equipment). These restrictions reduced the HRGCA sample to about 14,000 events. Finally, we retained in the HRGCA sample only grade crossing events in which a highway vehicle attempted to beat the freight train across the grade crossing. We identified these events as those where the road vehicle was impacted by the front of the freight train and was moving at the time of impact (rather than having been stuck unmoving at the crossing). This restriction resulted in a final HRGCA sample of 8,092 HRGCA events. Although some events can appear both in the HRGCA database and the REA database (when a grade crossing incident results in significant damage to rail equipment), there is no overlap between our REA and HRGCA samples because FRA classifies all such events as "highway-rail" incidents and we only extract REA events classified as derailments.

3.3 | Final sample construction

To ensure that our sample of control accidents matched our derailments sample as closely as possible (as required by the QIE method), we constructed our final analysis sample by including only events for which there was a geographic and temporal match between derailments and control accidents. Specifically, we retained in the final sample only derailments for which one or more control accidents in our control sample had occurred in the same county and year, and we retained only the control accidents that occurred in the same county and year as a derailment. This geographic and temporal matching resulted in a final analysis sample composed of 2,758 events (1,073 derailments and 1585 control accidents). We carried out this geographic and temporal matching using the "exact" function of the Matchit package in the statistical programming language R. The distributions of train lengths for both derailments and control accidents in the sample are illustrated in Figure 1.

4 | ANALYSIS APPROACH

4.1 | QIE analysis

A traditional analysis of the influence of a factor on accident risk would estimate the odds of an accident given the presence of the factor of interest relative to the odds in the absence of the factor. Thus, the odds ratio would be determined by the following formula:

$$\frac{\#\textit{accidents when the factor is present} \,/\, \#\textit{non-accident exposures when the factor is present}}{\#\textit{accidents when the factor is absent} \,/\, \#\textit{non-accident exposures when the factor is absent}}. \quad (1)$$

Thus, the odds ratio of derailment for a train of a certain length (length 1) relative to a reference length (length 2) could be estimated as

$$\frac{\textit{derailments by trains of length } 1 \,/\, \textit{safely completed trips by trains of length } 1}{\textit{derailments by trains of length } 2 \,/\, \textit{safely completed trips by trains of length } 2}. \quad (2)$$

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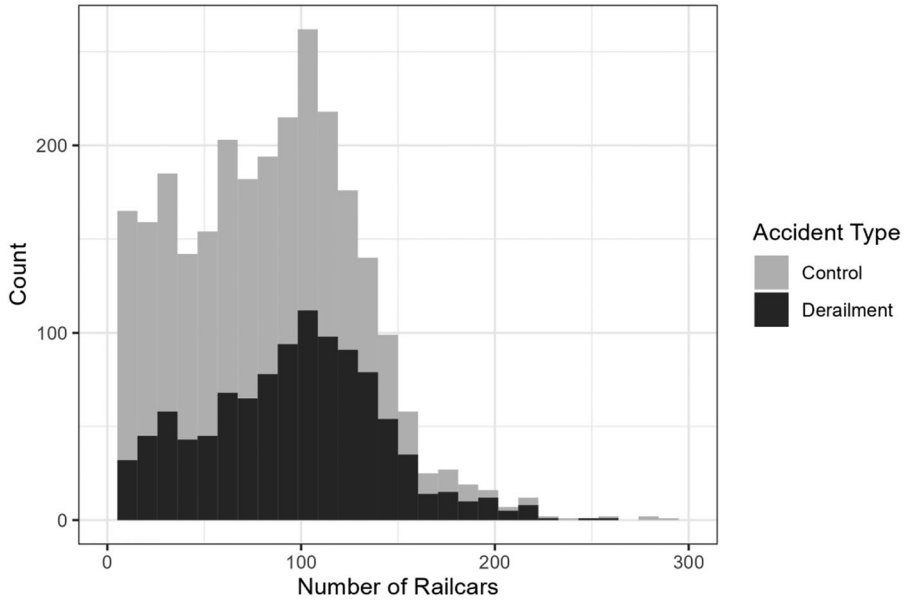


FIGURE 1 Distributions of the lengths of trains involved in derailments and control accidents.

The REA database contains data on train length. These data can be used to determine the number of derailments that have occurred by trains of different lengths. However, data on how many safely completed, non-accident trips have been made by trains of different lengths (exposure data) are not readily available, making analysis of the relationship between train length and derailment risk impossible using traditional techniques. We overcame the lack of available exposure data by train length by employing the QIE method and identifying a type of control accident whose occurrence is unrelated to the factor being studied. Since the control accident type is assumed to be closely correlated with exposure but independent of the factor of interest, the control accidents provide an excellent estimate of exposure to accident risk, acting as a quasi-random sample of exposures (Jiang et al., 2014; Keall & Newstead, 2009; Leslie et al., 2021; Stamatiadis & Deacon, 1997). Using incidence of the control accident as a proxy for exposure to risk, the relationship between a factor of interest and the odds of a type of accident of interest may then be estimated as

$$\frac{\begin{array}{c}\textit{accidents of interest when factor is present}/\\ \textit{control accidents when factor is present}\end{array}}{\begin{array}{c}\textit{accidents of interest when factor is absent}/\\ \textit{control accidents when factor is absent}\end{array}} \quad (3)$$

As discussed above, we identified "beat the train" grade crossing accidents as a good control accident type for our analysis. Studies of the causes of grade crossing accidents point to a number of factors that affect the likelihood of grade crossing accidents, including driver characteristics and road vehicle characteristics, but no study that we could find suggests train length as a possible contributing factor (Davey et al., 2008; McCollister & Pflaum, 2007; Oh et al., 2006). We summarize again the two primary reasons why this accident type can serve as a control accident type as follows: (1) because road vehicle drivers very rarely have the visibility perspective to gauge the length of an oncoming train (McCollister & Pflaum, 2007; Oh et al., 2006), the likelihood that the driver will attempt to beat the train should be independent of train length, (2) given that freight trains of any length have very long stopping distances (Bentley & Bentley, 2007), the driver of a freight train of any length would be unable to slow a train significantly in the time between observing the road vehicle attempting to cross the tracks and impact. Thus, we concluded that train length was sufficiently unrelated to "beat the train" grade crossing accidents to make this type of accident an effective control accident for our analysis of derailments and thus serve as a quasi-random sample of exposure data.

Given that QIE has not previously been used to study rail accidents, we carried out a simulation to explore the conditions under which QIE analysis of derailments would result in unbiased versus biased estimates of the influence of train length on derailment. To carry out this simulation analysis, we created nine different samples of simulated data representing every combination of train length being positively associated, negatively associated, or independent of both derailments and control accidents. We then analyzed the relationship between train length and derailment risk in the simulated data using both exposure-based analysis of the full samples (which is possible with the simulated data because they contain non-accident trips as well as trips that result in accidents) and QIE analysis of only the subsamples of the simulated trips that result in a derailment or a control accident. We then compared the relationship between train length and derailment risk in a sample for the exposure-based analysis (which is unbiased) compared to that for the QIE analysis (which will be biased if the QIE assumptions are not met).

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Results of the simulation analysis showed that when the risk of the control accident is independent of train length, the results of the exposure-based analysis and the QIE analysis are virtually identical, indicating that the QIE results are unbiased (as discussed above). However, when the control accident risk is positively associated with train length, the QIE analysis results are biased downward, and when the control accident risk is negatively associated with train length, the QIE analysis results are biased upward. Full details of the simulation analysis and results are reported in Appendix A.

The simulation results suggest that if our assumption that the risk of the occurrence of the control "beat the train" type of accident is independent of train length is not accurate, the QIE analysis results of the relationship between train length and derailment will be conservative (biased downward) if control accidents are more likely to occur for longer trains. In particular, if drivers are more likely to try to beat longer trains across a grade crossing because they can see how long a train is and because waiting for a longer train would take more time, then the results of the QIE analysis would be conservative. On the other hand, the size of the relationship between train length and derailment in the QIE analysis results will only be inflated in the case that the risk of the control accident is reduced for longer trains, that is, if drivers are less likely to try to beat longer trains across a grade crossing. It seems more likely that drivers would be more (rather than less) likely to try to beat longer trains, if indeed there is an association between train length and "beat the train" accidents. Thus, the simulation results demonstrate that even if our assumption that risk of a control accident is independent of train length does not hold, the QIE results presented below would be conservative (rather than inflated) estimates.

4.2 | Variables

Following standard QIE methods, we carried out our analysis of the final sample using logistic regression, with an indicator variable that took a value of 1 for derailments and a value of 0 for control accidents as the dependent variable. The independent variable in the analysis was train length measured in the number of railcars composing the train. We included in the analysis as controls a set of variables that have been shown in prior work to influence derailments or that were relevant to our context. First, given prior work showing that track class influences derailment rate (Liu et al., 2017; Nayak et al., 1983; Wang et al., 2020), we included a set of indicator variables for the class of the track on which each accident occurred. Track classes in our sample included FRA track classes 1–10 (the omitted category). Second, since prior work finds an effect of the method of operation on derailment (Liu et al., 2017), we controlled for method of operation (signaled or un-signaled) as an indicator variable. Third, to account for the possible effects of visibility on derailments and grade crossing incidents, we included a control for the visibility conditions at the time of the incident (dawn-the omitted category, day, dusk, or dark). Fourth, because trains transporting hazardous materials may be managed with extra precautions (Zhang et al., 2022), we included an indicator variable that takes a value of one for trains transporting any hazardous materials and a value of zero otherwise. Fifth, we included a control for the number of locomotives in the train (per 100 railcars). To control for temporal effects on derailment, we included fixed year and month effects. Finally, to account for variation in derailment risks across railroads, we included fixed railroad effects in the model. Unfortunately, we were unable to include a control for traffic density or whether a train was loaded or unloaded because, although the REA database reports these variables, the HRGCA database does not. Nonetheless, we expect that our geographic matching of derailments and control accidents partially controls for these factors.

We considered several different functional forms for modeling the relationship between train length and derailment risk by testing linear, quadratic, cubic, logarithmic, and exponential transformations of train length. Because the logarithmic transformation produced the best model fit, we employed this functional form in the reported models. However, the reported results are robust to this modeling choice as the same pattern of results is obtained when any of the other functional forms are used instead. The logistic regression models were estimated using the glm function in R. The relationship between train length and derailment odds ratio estimated using the logistic regression model is virtually identical to that obtained estimating the basic QIE odds ratio using the following equation:

$$\frac{\begin{array}{l}\textit{derailments among trains of length 1}/\\ \quad\textit{control accidents among trains of length 1}\end{array}}{\begin{array}{l}\textit{derailments among trains of length 2}/\\ \quad\textit{control accidents among trains of length 2}\end{array}}. \tag{4}$$

5 | RESULTS

5.1 | QIE logistic regression results

The results of the logistic regression model are presented in Table 1. Model 1 shows the results for the full sample, model 2 for only class 1 railroads (those with greater than $943.9 M in annual revenue), and model 3 for only smaller (class 2 and class 3) railroads.

In Model 1, the coefficient for train length for the full sample is positive and significant, indicating the risk of a train experiencing a derailment increases as train length goes up. To illustrate the magnitude of this positive relationship, it is helpful to compare the odds of derailment for a train of a given length relative to that of a baseline train length. As an example, we chose a 50-car train as the baseline train length and calculated odds ratios for the odds of derailment for trains of between 1 and 250 cars in length relative to that of a 50-car train. These odds ratios (along with 95% confidence intervals) are presented in Figure 2. Odds of derailment as well as

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TABLE 1 Results of the quasi-induced exposure (QIE) logistic regression analysis.

	Model 1			Model 2			Model 3		
	Full sample			Class 1 railroads			Class 2 & 3 railroads		
Variable	Coef	se	*p*	coef	se	*p*	coef	se	*p*
Train length (logged)	1.15	0.10	0.000***	1.19	0.11	0.000***	1.37	0.34	0.000***
Track class 1	−1.01	0.63	0.108	−1.47	1.17	0.210	−0.19	0.89	0.834
Track class 2	−2.00	0.63	0.001**	−2.66	1.16	0.022*	−0.71	0.91	0.434
Track class 3	−2.86	0.63	0.000***	−3.47	1.16	0.003**	−2.55	1.03	0.013*
Track class 4	−2.97	0.63	0.000***	−3.58	1.16	0.002**	−2.28	1.31	0.082
Track class 5	−2.64	0.64	0.000***	−3.27	1.17	0.005**			
Track class 6	−3.75	1.02	0.000***	−4.37	1.41	0.002**			
Track class 8	−20.14	2400	0.993	−16.78	325	0.959			
Track class 9	14.13	2400	0.995	9.78	325	0.976			
Signaled operation	0.73	0.11	0.000***	1.01	0.12	0.000***	−1.88	0.47	0.000***
Visibility—Day	0.01	0.15	0.947	−0.02	0.16	0.879	1.08	0.75	0.148
Visibility—Dusk	0.03	0.20	0.877	0.02	0.20	0.919	1.34	1.12	0.233
Visibility—Dark	0.38	0.16	0.017*	0.37	0.16	0.023*	0.85	0.72	0.236
Hazmat	0.24	0.10	0.011*	0.23	0.10	0.019*	0.44	0.48	0.359
Locomotives per 100 cars	0.02	0.01	0.017*	0.03	0.01	0.002**	0.02	0.02	0.511
Year fixed-effects	Included			Included			Included		
Month fixed-effects	Included			Included			Included		
Railroad fixed-effects	Included			Included			Included		

*p<.05; **p<.01; ***p<.001.

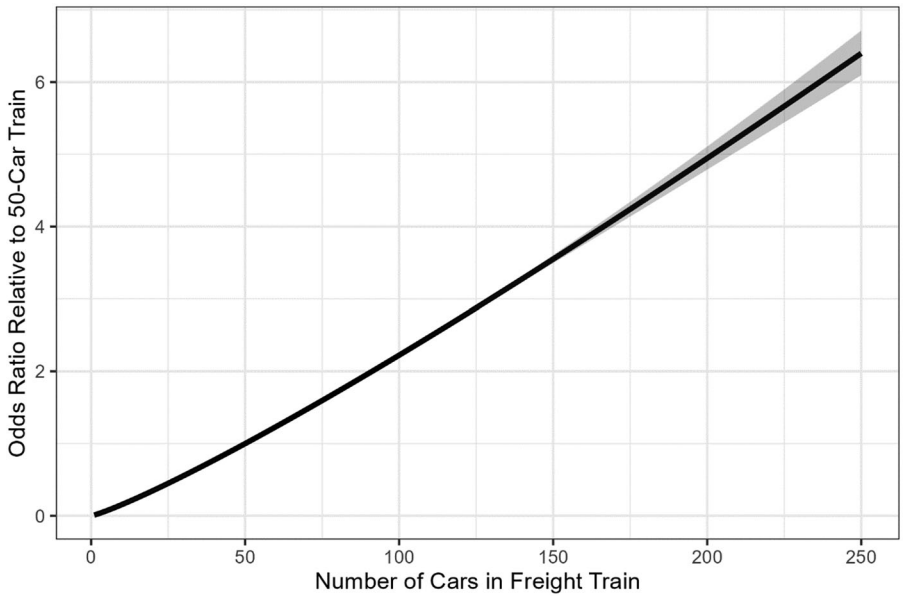


FIGURE 2 The odds ratio of derailment (along with 95% confidence interval) by number of cars in a train relative to a 50-car train.

95% confidence intervals were computed using the "predict" function in R based on the results from Model 1 in Table 1. The figure shows a positive relationship between train length and the odds of derailment. A value of 2 in the figure (for a roughly 90-car train) reflects 2 times (or double) the odds of derailment compared to a 50-car train.

Several of the control variables are also significantly related to the odds of derailment in Model 1. The odds of derailment are lower for higher track classes as found in prior work (Liu et al., 2017; Nayak et al., 1983; Wang et al., 2020). On the other hand, derailment odds are higher when the method of operation is signaled rather than non-signaled.

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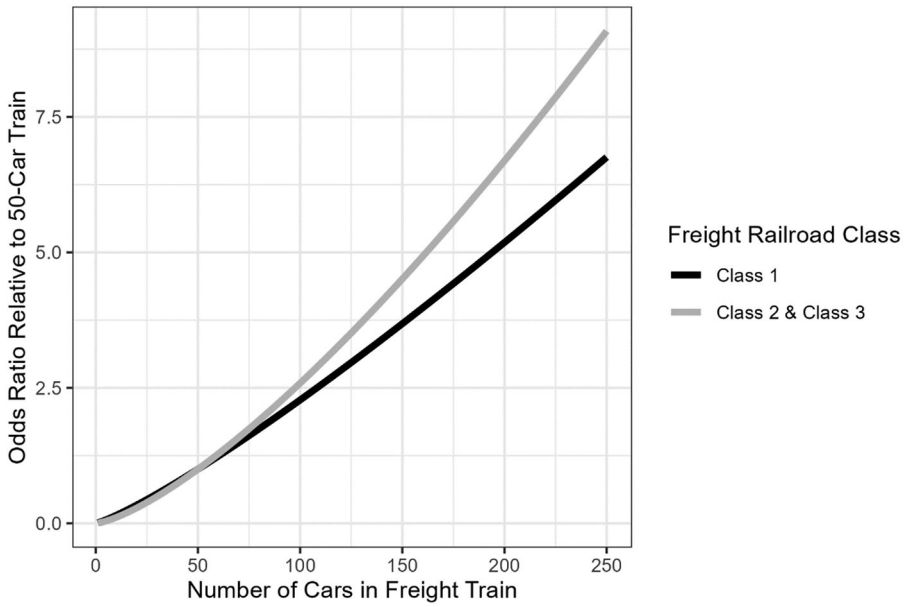


FIGURE 3 The odds ratio of derailment by number of cars in a train relative to a 50-car train for class 1 railroads compared with class 2 and 3 railroads.

This finding is not in line with prior work (e.g., Liu et al., 2017), but probably reflects the influence of mode of operation on "beat the train" highway-rail crossing accidents in that drivers are less likely to try to beat trains in areas where trains are signaled. The odds of derailment increase when visibility conditions are categorized as "dark," relative to the other visibility conditions (dawn, day, and dusk), and the odds of derailment also increase as hazardous material is present and as the number of locomotives per 100 railcars increases.

Model 2 reports results for logistic analysis of the subsample of our data that only includes data on class 1 (large) railroads, and Model 3 reports results for the subsample of smaller class 2 and class 3 railroads. In both models, the train length coefficient is positive and significant, indicating a meaningful positive relationship between train length and derailment risk. The magnitude of this relationship is illustrated in Figure 3, which shows the odds ratios of derailment for trains of varying lengths relative to a baseline 50-car train for both class 1 and class 2 and 3 railroads. The odds ratios are estimated using the "predict" function in R using the results from Models 2 and 3 in Table 1. The relationship between train length and derailment odds for class 1 railroads is virtually identical to that for the full sample (which is not surprising given that the bulk of the sample came from class 1 railroads), whereas the relationship for class 2 and 3 railroads is somewhat more positive. This result indicates that the positive relationship between train length and derailment odds is somewhat stronger for class 2 and 3 railroads compared to class 1 railroads.

5.2 | Accounting for the effect of train length on rail-system-wide derailment exposure

The results displayed above suggest a strong positive relationship between train length and derailment risk. However, these results represent this relationship only for an individual freight train and, thus, may overstate the system-wide impact of train length on derailment risk for the whole freight rail system because the use of longer trains allows the same amount of freight to be transported on fewer trains (Zhang et al., 2022). The use of longer trains inherently implies fewer train trips overall, corresponding to a reduction in the aggregate exposure to derailment risk. This exposure reduction effect will operate in the opposite direction to the positive relationship between train length and derailment risk. The exposure reduction associated with freight trains of different lengths relative to a baseline 50-car train is calculated as exposure equals 50 cars divided by the number of railcars in the train length of interest. Thus 25-car trains would have twice the exposure of 50-car trains and 100-car trains would have half of the exposure. This exposure effect is illustrated in Figure 4 for trains of varying lengths.

This effect of longer trains on derailment exposure must be accounted for to understand the full relationship between train length and derailment risk for the overall U.S. rail system. An aggregate estimate of the overall relationship is estimated by multiplying the odds ratio of derailment for a given train length (relative to the baseline 50-car train) by the derailment exposure effect for that train length. This aggregate estimate is the most complete representation of the full relationship between train length and derailment risk because it accounts for both the increase in derailment risk for individual trains as they become longer and the decrease in derailment exposure that longer trains create in the overall freight rail system. This aggregate relationship (relative to a baseline 50-car train) is illustrated in Figure 5 (along with its 95% confidence interval) based on the results of the QIE logistic regression analysis in Model 1 of Table 1.

The aggregate relationship between freight train length and odds of derailment is positive and meaningful in size. The

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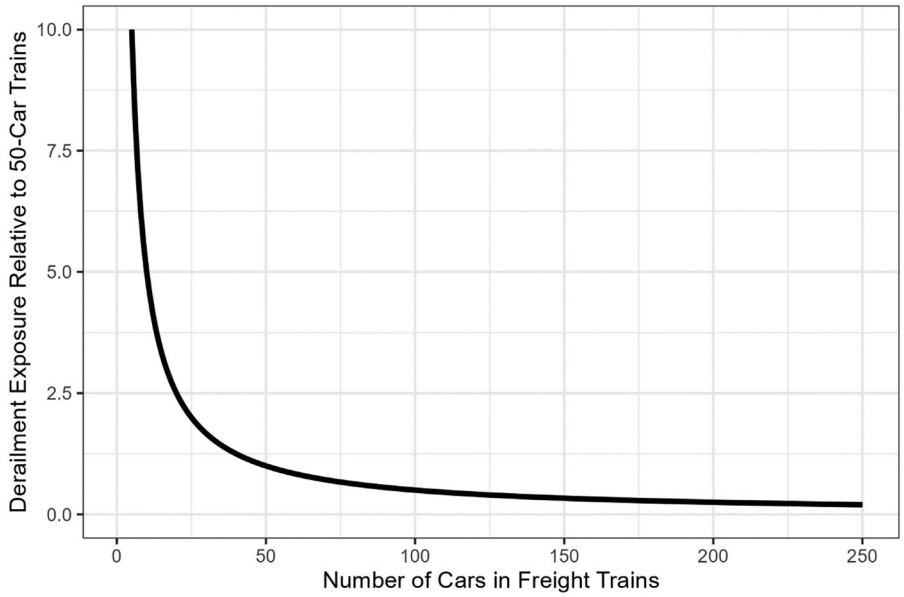


FIGURE 4 The derailment exposure of trains of varying lengths relative to 50-car trains.

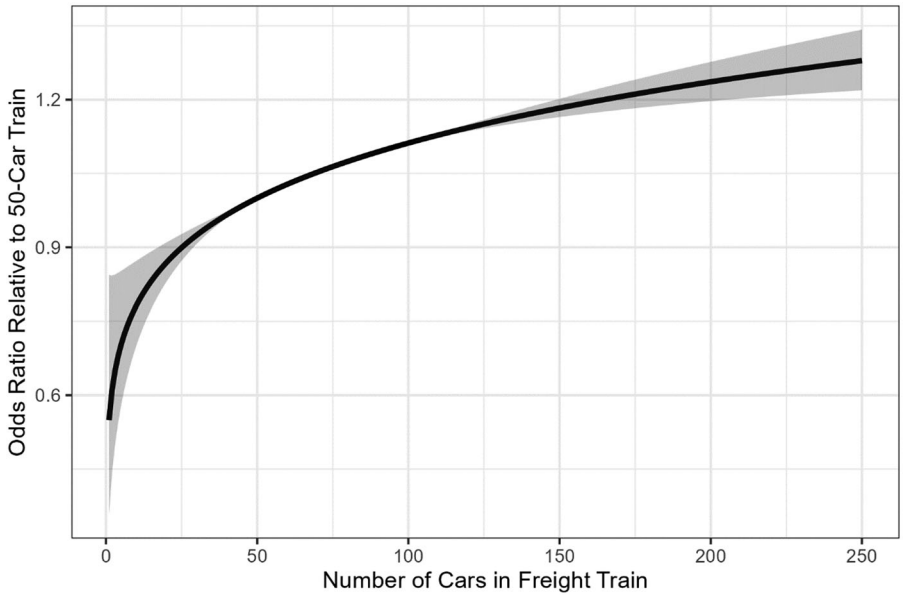


FIGURE 5 The aggregate derailment odds ratio for trains of varying lengths relative to 50-car trains accounting for the reduction in derailment exposure for longer trains.

results show that 100-car trains are associated with 1.11 (95% CI 1.10–1.12) times the derailment odds of 50-car trains (or a 11% increase), accounting for the exposure reduction given that only half as many 100-car trains would be needed to transport the same amount of freight. For 200-car trains, the derailment odds increase by about 24% (OR 1.24, 95% CI 1.20–1.28) net of the exposure reduction. Thus, longer trains are associated with increased derailment risk even with the reduction in exposure accounted for. This increase in derailment risk is statistically significant.

The aggregate relationship between train length and derailment risk (relative to a baseline 50-car train) for class 1 compared with class 2 and 3 railroads based on the results of the QIE logistic regression analysis in Models 2 and 3 of Table 1 is illustrated in Figure 6. As before, the positive relationship between train length and derailment risk is stronger for trains operated by class 2 and 3 railroads relative to those operated by class 1 railroads.

We should note that our analysis used the number of railcars in the train as its measure of train length. This is a common measure of train length, but other measures such as linear feet are also commonly used. Our results may be translated to train length in linear feet by multiplying the number of cars by an average car length of 62 ft (Dick et al., 2021).

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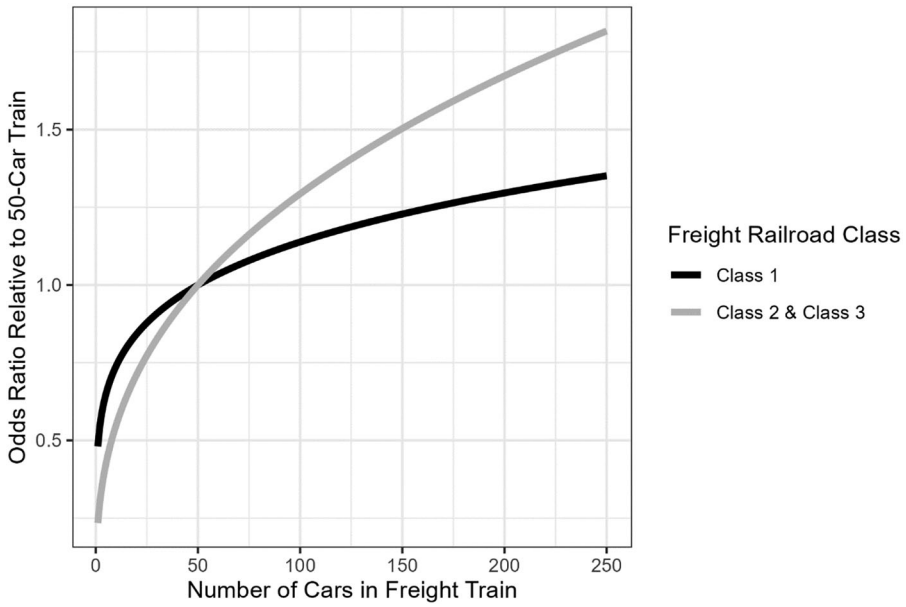


FIGURE 6 The aggregate derailment odds ratio for trains of varying lengths from class 1 compared to class 2 and 3 railroads relative to 50-car trains accounting for the reduction in derailment exposure for longer trains.

6 | CONCLUSIONS

This article describes a quantitative method for analyzing the risk of derailment when considering train length. It provides a statistical procedure to examine the available accident data from the freight train industry to support policy making to address derailment risk. Derailment risk, however, is just one factor that needs to be considered by policy makers. Longer freight trains have many significant benefits for the rail system relative to shorter freight trains, including greater fuel efficiency, lower emissions per ton transported, and lower operational costs than both shorter trains and many other forms of transportation (United States Government Accountability Office [US GAO], 2019; Muller et al., 2022). The operation of longer freight trains also comes with costs such as increased wait times at railroad grade crossings for road vehicles in communities where freight trains frequently operate (United States Government Accountability Office [US GAO], 2019). Additionally, as recent cases like the East Palestine derailment demonstrate, derailments can have significant negative environmental and health impacts on communities, although rail remains a safer mode of transportation for hazardous chemicals than other options (Bagheri et al., 2014). As the Railway Safety Act of 2023 is debated including the pros and cons of longer trains, an important consideration in these debates is the additional risk of derailment in the system that comes with longer trains. Until this time, quantifying this relationship has been elusive. However, the model described here provides a process for analyzing this relationship, and the results presented suggest a clear, monotonic, and positive relationship between freight train length and derailment risk. Even when accounting for the reduction in the number of freight trains operated when the average train is longer, longer freight trains are associated with an increase in the aggregate odds of freight train derailment.

Knowing the direction and estimated size of the relationship between train length and derailment risk is important information when considering the future development and regulation of freight rail transportation, as it allows derailment risk to be more accurately weighed against the other costs and benefits of longer freight trains for the overall system. Additionally, understanding the risk could spur additional innovations in preventive measures. As demonstrated by the differences in risk between trains operated by larger, class 1 railroads compared to small railroads, more stringent standards and better maintenance can help address the risk of longer trains. This research could encourage the FRA to collect additional data on length of trains not involved in accidents so that the exposure risk can be further studied.

Finally, this research demonstrates the applicability of QIE to safety incident analysis beyond its previous use in the study of road traffic accidents. Although the procedure has broader applicability to many other industries, the limitations are that incident data for the case study of interest and a control that is independent of the factor of interest are needed, and the results are relative ratios not explicit rates. Therefore, the technique can be useful in many situations but not for all applications.

ACKNOWLEDGMENTS

The research was supported by the National Science Foundation Grant: 2051685; however, any opinions, findings, and conclusions or recommendations in this document are those of the authors.

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How to cite this article: Madsen, P. M., Dillon, R. L., Triantis, K. P., & Bradley, J. A. (2024). The relationship between freight train length and the risk of derailment. *Risk Analysis*, 1–13. https://doi.org/10.1111/risa.14312

APPENDIX A

As noted above, quasi-induced exposure (QIE) is an analytic technique designed to study how factors influence the likelihood of accident occurrence in contexts where exposure data are limited or unavailable. QIE is an accepted methodology in the study of road accidents but does not appear to be well known in the broader risk analysis community. For example, we can find no examples of QIE being used to study rail accidents.

Here, we use QIE to study the influence of train length on the likelihood of derailment. Our QIE results suggest a significant positive relationship between freight train length and the risk of a derailment. However, the validity of this finding is contingent on the key assumption of the QIE method being met—namely, that the "control" accident type is genuinely independent of train length. Given the data limitations that require us to use QIE analysis in the first place (i.e., the lack of exposure data by train length), we cannot obtain the data necessary to fully test this assumption empirically. To explore the ramifications for our QIE analysis if this assumption is not

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met, we conducted an analysis of simulated data allowing for the observation of exposure by train length. In the analysis of the simulated data, we explored how results of a QIE analysis on a subset of a data set would differ from those of a traditional, exposure-based analysis of the whole data set.

We first simulated nine different samples of simulated data representing every combination of train length being positively associated with, negatively associated with, or independent of both the risk of derailments and control accidents. Each of the 9 simulated samples contained 500,000 observations of simulated train trips. In all 9 samples, the length of the freight train making a given trip was randomly drawn from a normal distribution with a mean of 100 cars and a standard deviation of 25 cars. Indicators of whether a given trip ended in a derailment or a control accident were randomly drawn from binomial distributions with different levels of risk. The risk of derailment was set as 0.001 (or 1 in 1000 trips) for the conditions in which derailment was assumed to be independent of train length, $0.001 \times$ (train length/100 cars) for the conditions in which derailment was assumed to be positively associated with train length, and $0.001 \times$ (100 cars/train length) for the conditions in which derailment was assumed to be negatively associated with train length. Because control accidents were more common in our data than derailments, the risk of a control accident was set at 0.005 when control accidents were independent of train length, $0.005 \times$ (train length/100 cars) when control accidents were positively associated with train length, and $0.005 \times$ (100 cars/train length) for conditions where control accidents were negatively associated with train length. For each simulated observation, a train length was randomly determined and then given the train length, whether that train observation was a derailment accident or a control (crossing) accident was determined.

We then analyzed the relationship between train length and derailment risk in each of the simulated data samples using logit regression with the derailment indicator as the dependent variable and the train length as the independent variable. First, exposure-based analysis was carried out via logit regression of the full sample. Second, QIE analysis was carried out via logit regression of the subsample of trips that ended in either derailment or a control accident. This second model mimics the real-world conditions under which QIE is used, when data on accidents is available but data on non-accident exposure is not. Because the exposure-based analyses return unbiased estimates of the relationships between train length and derailment risk, comparison between the results of the exposure-based analysis and the QIE analysis shows the conditions under which the QIE analysis results are biased and unbiased.

Table A1 presents the results of the analysis of the nine different simulated samples representing different assumptions about the relationships between train length and derailments and control accidents.

As can be seen in the table, when train length is independent of control accident risk, the QIE analysis results are virtually identical to the exposure-based analysis results, showing that in that case, the QIE results are unbiased. This finding is fully in line with our assumptions about the need for the control accident to be independent of the independent variable in QIE analysis. However, when train length is positively related to control accident risk, the QIE analysis results are biased downward, such that the relationship between train length and derailment risk appears more negative in the QIE analysis than in the exposure-based analysis. And when train length is negatively related to control accident risk, the QIE analysis results are biased upward, such that the relationship between train length and derailment risk appears more positive in the QIE analysis than in the exposure-based analysis.

Given that we observe a significant positive relationship between train length and derailment risk in the QIE analysis of our real-world data, if the risk of control accidents was actually positively related to train length, our reported results would be conservative, and the true relationship between train length and derailment risk would be even more strongly positive than what we report. In this case, the magnitude of the relationship we report in the main analysis may be conservative, but the direction of this relationship would remain correct. On the other hand, if the risk of control accidents was negatively related to train length, our reported results could be completely spurious in that a false positive relationship between train length and derailment risk could be created by the QIE methodology in this case. Thus, the greatest threat to the validity of the reported results is the possibility of a negative effect of train length on the risk of the control, "beat the train" grade crossing, accidents.

We remain convinced that it is most likely that the occurrence of "beat the train" grade crossings is indeed independent of train length for the reasons argued in the article. However, even if this logic is inaccurate and drivers' decisions to attempt to beat trains across grade crossings are related to train length, it seems more likely that attempts to beat the train (and thus the likelihood of being hit by the train) would be more common for longer trains than for shorter trains because the amount of time that drivers could save by beating a train would be greater for longer trains. It appears unlikely that if drivers could perceive the length of an approaching freight train, they would preferentially choose to attempt to beat shorter trains relative to longer trains. Thus, the simulation results suggest that even if the assumptions we made in conducting the QIE analysis do not fully hold, the most likely result would be that the reported QIE results are somewhat conservative in magnitude but correct in direction, rather than spurious.

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TABLE A1 Results of analysis of simulated data. Exposure coef. stands for the coefficient of train length in the exposure-based analysis. QIE coef. stands for the coefficient of train length in the QIE analysis.

Condition	Exposure coef.	*p*-Value	QIW coef.	*p*-Value	QIE sample size
Derail = Positive; Control = Positive	0.006	0.000	−0.004	0.045	2999
Derail = Positive; Control = Independent	0.012	0.000	0.012	0.000	2993
Derail = Positive; Control = Negative	0.011	0.000	0.022	0.000	3110
Derail = Independent; Control = Positive	−0.001	0.483	−0.012	0.000	3027
Derail = Independent; Control = Independent	0.002	0.390	0.002	0.400	2965
Derail = Independent; Control = Negative	0.000	0.988	0.011	0.000	3226
Derail = Negative; Control = Positive	−0.011	0.000	−0.020	0.000	3043
Derail = Negative; Control = Independent	−0.012	0.000	−0.011	0.000	3064
Derail = Negative; Control = Negative	−0.013	0.000	0.001	0.770	3284

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EXHIBIT 28

TechXplore

MAY 29, 2024

Is a train's risk of derailment affected by its length?

by Wiley



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Longer freight trains are more likely to derail compared with shorter trains, according to new research published in *Risk Analysis*. The increased risk held even after accounting for the need for fewer trains if more cars were on each train.

For the study, investigators assessed information on US freight train accidents between 2013–2022 from Federal Railroad Administration databases. The team found that running 100-car trains would lead to an 11% higher risk of derailment compared with running 50-car trains, even when accounting for the fact that only half as many 100-car trains would need to run. For 200-car trains, the risk was 24% higher than for 50-car trains.

"Because the Federal Railroad Administration doesn't collect data on the length of trains that aren't in accidents, this research involved some innovative modeling that we explain in detail in the paper, but the increased risk of longer trains is clearly shown," said corresponding author Robin L. Dillon, Ph.D., of Georgetown University.

More information: The Relationship between Freight Train Length and the Risk of Derailment, *Risk Analysis* (2024). DOI: 10.1111/risa.14312

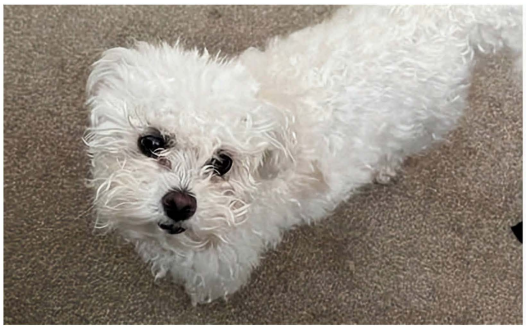
Journal information: Risk Analysis

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Citation: Is a train's risk of derailment affected by its length? (2024, May 29) retrieved 10 January 2026 from https://techxplore.com/news/2024-05-derailment-affected-length.html

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EXHIBIT 29



Advertisement

TRANSPORTATION

'The longer the train, the heavier the train' — Ohio disaster calls attention to freight's growing bulk

The sheer length of the 150-car train that went off the rails Feb. 3 is just one factor investigators are expected to consider amid the unfolding ecological disaster near the Ohio-Pennsylvania border.



A large plume of smoke rises over East Palestine, Ohio, after a controlled detonation of a portion of the derailed Norfolk Southern trains Monday, Feb. 6, 2023. | Gene J. Puskar/AP Photo

By TANYA SNYDER
02/16/2023 04:30 AM EST
Updated: 02/16/2023 01:21 PM EST

The toxic train derailment in East Palestine, Ohio, is drawing new attention to the dangers of increasingly long freight trains — part of a series of cost-savings efforts by freight railroads that have drawn scrutiny from the industry's critics.

The sheer bulk of the 150-car train that went off the rails Feb. 3 is just one factor investigators are expected to consider amid the unfolding ecological disaster near the Ohio-Pennsylvania border, which caused a massive fireball, forced an evacuation and has left a lingering odor, fears of lasting contamination and thousands of dead fish. But union officials, regulators and congressional researchers say the industry's trend toward ever-growing train lengths is causing a host of safety concerns that regulators need to address.

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"The longer the train, the heavier the train, the more wear and tear it puts on the actual rail itself, as well as the equipment," said Jared Cassity, a legislative director for the country's largest rail union, SMART-Transportation Division. "We're seeing more wear and tear. We're seeing more unintended train separations, which is where the train breaks apart."

The Ohio derailment is still under investigation by multiple agencies, including the Department of Transportation, the Environmental Protection Agency and the National Transportation Safety Board. The NTSB, an independent agency, has said preliminarily that an overheated wheel bearing on one of the cars is partially the culprit for the derailment.



However, derailments like these typically have multiple points of failure, and the NTSB's investigation will likely take over a year to complete. Such NTSB probes typically examine any conceivable cause that could have led to a crash, including equipment malfunctions, poor system design, the lack of safety precautions, inadequate training, crew fatigue and myriad other factors.

"One hundred fifty cars is a really, really significant [number of cars]," said Sarah Feinberg, who dealt with multiple oil-train disasters and a fatal Amtrak derailment as leader of the Federal Railroad Administration under Barack Obama. "For years, the FRA and other safety regulators have raised concerns about trains of that size."

Sens. Marco Rubio (R-Fla.) and J.D. Vance (R-Ohio) raised the length issue in a letter Wednesday to Transportation Secretary Pete Buttigieg, noting that only a handful of workers were on the train before it went off the tracks.

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"[I]t is not unreasonable to ask whether a crew of two rail workers, plus one trainee, is able to effectively monitor 150 cars," they wrote.

Indeed, 150 cars is the FRA's threshold for classifying a train as "very long," even though no formal definition exists. In a 2019 study, the Government Accountability Office said 150 cars is more than twice the average length of freight trains operated by major railroads from 2008 through 2017. The GAO

2008, and noted that some stretch to nearly three miles long.

The freight rail industry's main trade group dismissed concerns about length. "Comparable length trains have been safely operating for decades and the industry's safety record has seen dramatic improvements over those same decades," said Jessica Kahanek, a spokesperson for the Association of American Railroads.

But the GAO authors note multiple concerns about train length, including that it can hamper crews' ability to operate the trains, it can take longer for brakes to stop them, and safety risks can arise when firetrucks can't get past multiple blocked rail crossings. The FRA wrote in a December report that it lacks the data "to determine safety consequences" of long trains, and in some cases doesn't have enough authority to act on them.

The National Academies of Sciences, Engineering and Medicine is also studying the issue.

Others, especially labor unions, say the trains are too long for crews on opposite ends to communicate with each other, and that workers on board sometimes can't hear track-based warning alarms up ahead. "Our radios aren't built for the distances that these trains are built for," Cassity said.

At the same time, one industry analyst noted, freight railroads such as Norfolk Southern, which operated the trains in the Ohio disaster, cannot refuse to carry hazardous materials such as vinyl chloride, one of the toxic, flammable chemicals released in East Palestine. That's because railroads are considered "common carriers," which are obligated to transport any legally permitted product.

"The government does not allow Norfolk Southern and the other railroads to carry hazardous materials," said rail analyst Tony Hatch. "It compels them to carry them."

Republican Ohio Gov. Mike DeWine pledged during a television interview Wednesday to make Norfolk Southern "pay for everything" needed to deal with

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the aftermath of the disaster, while Vance said in a statement that questions remain about the train's brakes and DOT's "regulatory approach to our nation's rail system."



Feinberg also touched on the brake issue, saying she believes that a type of advanced brake could have lessened the damage from the Ohio disaster.

The DOT under Obama had issued a rule in 2015 requiring railroads to use those kinds of electronically controlled pneumatic brakes on certain especially dangerous trains, in response to a spate of fiery derailments of freight cars transporting crude oil. But the Trump administration repealed the braking mandate in 2017, after a National Academy of Sciences study failed to conclusively determine that ECP braking technology was superior to others.

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The type and location of locomotives used to brake trains is especially important for long trains. The NTSB final report on a 2017 derailment in Pennsylvania faulted the use of hand brakes and the arrangement of freight cars in that accident involving a 178-car train, which also released hazardous chemicals and forced the evacuation of a nearby town.

"I and many others have said for many years that an ECP braking system is a much safer braking system to have on" any kind of "significant" train load, Feinberg said.

Norfolk Southern defended the integrity of the train in the Ohio derailment, including its braking configuration. Spokesperson Thomas Crosson told POLITICO that the weight distribution of the train that derailed in Ohio "was uniform throughout" and that a braking locomotive was placed mid-train to help it stop properly.

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The Ohio derailment has also brought intensifying criticism of Buttigieg, including from conservative media outlets that slammed him for not speaking publicly about the accident until 10 days after it happened. Progressives like Rep. Ilhan Omar (D-Minn.) are also laying the incident in Buttigieg's lap and calling on him to take "direct action."

After days of calls for Buttigieg to engage more, the secretary weighed in Monday on Twitter to express concern about the people in and near East Palestine, whose "lives were upended through no fault of their own." He also rattled off the multiple federal agencies involved in responding.



Railroad unions say the main problem is that corporate cost-cutting measures are eating into safety and raising the likelihood of disaster. This theme — corporate cost-cutting over safety — also underpinned part of why railroad unions threatened to strike last year.

Unions in particular target railroads' implementation during the past decade of "precision scheduled railroading," an operating model that focuses on minimizing workforce costs and maximizing equipment efficiency, including not leaving train cars idle.

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Among the workforce cuts produced by this drive for efficiency were 40 percent of equipment maintenance workers, as GAO reported in December.

"We've heard reports from inspectors that the time they are allotted to inspect both sides of a rail car has decreased by 75 percent — from 2 minutes to as little as 30 seconds — thanks to the rail industry's profits-over-people business

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model," said Greg Regan, president of the AFL-CIO's Transportation Trades Department.

Kahanek from AAR responded that not only are trains inspected before departing a rail yard, technology along the track constantly assess each train's soundness and safety as they move throughout the system.

Precision scheduling and other cuts made in the name of efficiency have worsened freight rail's problems, said former Rep. Dan Lipinski (D-Ill.), who chaired the House railroad subcommittee. "That was a huge change that reverberated throughout the entire North American freight rail industry," he said. "And I think there has not been enough of a response by Congress to those changes."

Railroads have been losing workers since 2015 and 2016, when waves of layoffs started and those who remained were made to work longer and less predictable hours under challenging conditions. Union officials say they've seen many seasoned workers with decades of experience leave the industry in frustration — even forgoing lucrative railroad retirement benefits — and railroads are now scrambling to hire novices to take their place.

The EPA has told Norfolk Southern it's potentially liable under the Superfund clean law. But the agency said Sunday that the air in East Palestine is now safe to breathe.

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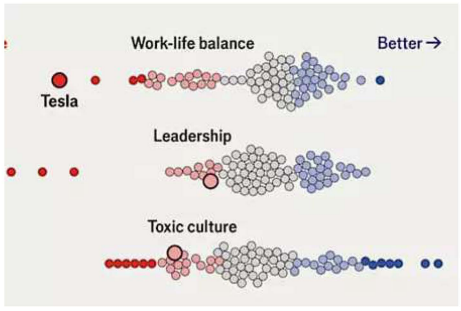
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United States Government Accountability Office



Report to Congressional Requesters

May 2019

RAIL SAFETY

Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact

GAO-19-443

GAO Highlights

Highlights of GAO-19-443, a report to congressional requesters

May 2019

RAIL SAFETY

Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact

Why GAO Did This Study

In 2017, the U.S. freight rail system moved over 1.5-billion tons of goods. The largest freight railroads—Class Is—dominate the industry and account for more than 90 percent of its annual revenue. In recent years, railroad workers and local communities have expressed safety concerns related to longer freight trains, and recent accidents involving such trains are currently under investigation by FRA. FRA does not currently place limits on freight train length.

GAO was asked to review the safety and other impacts of longer freight trains. This report examines: (1) changes in freight train length over time, (2) safety considerations for operating longer freight trains, and (3) the extent to which FRA is assessing any safety risks. GAO reviewed relevant statutes, regulations, and federal agencies' reports and plans; analyzed available data on freight train length from railroads; and interviewed federal officials and various stakeholders, including state and local officials and first responders from five states (selected to represent different railroads and regions), and officials from the railroad industry, unions, and advocacy groups.

What GAO Recommends

GAO recommends that FRA develop and implement a strategy to share the results of its study on longer trains and work with railroads to engage state and local governments to identify and reduce impacts of longer freight trains on highway-railroad crossings. FRA concurred with GAO's recommendations.

View GAO-19-443. For more information, contact Susan Fleming at (202) 512-2834 or flemings@gao.gov.

What GAO Found

Freight train length has increased in recent years, according to all seven Class I freight railroads. Data on train length are not publicly available; however data provided to GAO by two Class I railroads indicated that their average train length has increased by about 25 percent since 2008, with average lengths of 1.2 and 1.4 miles in 2017. Officials from all seven Class I railroads said they are currently operating longer than average trains on specific routes, although some said such trains are a small percentage of the trains they operate. One railroad said it runs a 3-mile-long train twice weekly. Officials identified increased efficiencies and economic benefits among the advantages of longer freight trains.

Stakeholders said that the arrangement of train cars and locomotives—known as "train makeup"—and the potential for blocking highway-railroad crossings are issues to consider to safely operate longer freight trains. To prevent derailment, stakeholders said it is important that longer trains are arranged appropriately and that crews are trained to operate them. While Class I railroads and others said that longer trains may decrease the frequency of blocked crossings, some state and local officials said these trains can prolong their duration, posing challenges for emergency responders unable to cross the tracks.

Emergency Vehicle Blocked by Freight Train at Rail Crossing



Source: National Industrial Transportation League – Photo by Bruce Ridley. | GAO-19-443

The Federal Railroad Administration (FRA) is studying the safety risks of and strategies for operating longer trains. As part of the study, FRA plans to analyze train-handling and braking capabilities under varying conditions. FRA officials said they plan to share their research results with relevant stakeholders; however, FRA currently has no documented strategy for sharing the results of its research. FRA officials are also analyzing which parts of the country are reporting frequently blocked crossings. However, FRA officials said they do not plan to use information from either of these efforts to determine whether longer freight trains might contribute to increases in blocked crossings, and the officials believe the issues are unrelated. Developing and implementing a strategy for sharing FRA's research results and identifying any potential impacts of longer freight trains on highway-railroad crossings would enable FRA and stakeholders to better determine what, if any, actions are needed to ensure the safe operation of longer freight trains.

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Abbreviations

AAR	Association of American Railroads
DOT	U.S. Department of Transportation
DP	distributed power
FRA	Federal Railroad Administration
NTSB	National Transportation Safety Board
STB	Surface Transportation Board

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

May 30, 2019

The Honorable Peter DeFazio
Chairman
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Daniel Lipinski
Chairman
Subcommittee on Railroads, Pipelines, and Hazardous Materials
Committee on Transportation and Infrastructure
House of Representatives

The Honorable André Carson
House of Representatives

The Honorable Jim Cooper
House of Representatives

The Honorable Terri Sewell
House of Representatives

The nation's freight railroad network is vital to the functioning of the economy. In 2017, the United States' freight rail system moved over 1.5-billion tons of goods across the country, including hazardous materials, bulk goods such as grain and coal, and consumer goods. Generally, railroads transport these goods safely. While freight-rail traffic has grown following the 2008 recession, train accidents have declined, according to the Federal Railroad Administration's (FRA) data,[1] with train accidents per million-train-miles decreasing by about 14 percent between 2008 and 2017.[2]

In recent years, railroad workers and communities have expressed concerns regarding the safety of railroads operating longer freight trains, some of which are nearly 3 miles long. These concerns include whether

[1]As one of nine U.S. Department of Transportation operating administrations concerned with intermodal transportation, FRA's mission is to enable the safe, reliable, and efficient movement of people and goods.

[2]According to FRA, a train-mile is the movement of a train—a locomotive or locomotives with or without railcars—the distance of 1 mile.

train crews are adequately trained to operate longer trains, the ability of long trains to effectively activate brakes, and the impacts on highway-rail at-grade crossings, also known as "grade crossings"—where streets and highways intersect with train tracks at the same level.[3]

Some recent accidents involving longer freight trains are under investigation by FRA, the federal rail-safety-regulating agency, and the National Transportation Safety Board (NTSB), an independent federal agency that investigates serious transportation accidents, including those involving rail. For example, in 2017, a freight train over 2 miles long consisting of 178 railcars of mixed freight—including flammable and hazardous liquid—derailed in Hyndman, Pennsylvania causing significant damage. NTSB is currently investigating many factors associated with the cause of the derailment, including the length, makeup, and operation of the train. Although FRA oversees various aspects of freight railroad safety, it has no specific regulatory requirements that limit train length or define what constitutes a "long" train.

You asked us to review the potential impacts on railroads, workers, and local communities of operating longer freight trains. This report examines

- what is known about changes in freight train length over time,
- views of selected stakeholders on safety considerations for operating longer trains and the potential impact of these trains on communities, and
- the extent to which FRA is assessing any safety risks of operating longer trains.

To address these objectives, we analyzed data provided by Class I railroads on average train-length in feet over time and reviewed documents and interviewed officials from all seven Class I railroads regarding their operation of longer trains.[4] As data on train-length in feet

[3]As of March 2019, more than 211,000 at-grade crossings existed in the United States, according to FRA.

[4]Freight railroads are classified by operating revenues. At present, Class I railroads are those having annual carrier operating revenues of approximately $447.6 million or more, of which there are currently seven: BNSF Railway, Canadian National, Canadian Pacific, CSX Transportation, Kansas City Southern, Norfolk Southern, and Union Pacific. This report is limited in scope to Class I freight railroads because they account for more than 90 percent of annual railroad-freight revenues and employ 90 percent of railroad employees.

are not publicly available, we requested information from these railroads. Five of the seven railroads provided data on average train-length in feet over time; however, only two railroads provided data for a period of at least 10 years.[5] We also analyzed data from the Association of American Railroads (AAR) to determine average number of railcars and weight per train for calendar years 2008 through 2017, the most recent year for which data were available.[6] These data are the only publicly available data on the number of railcars per train, and there are limitations to how the data can be used. For example, the average number of railcars per train cannot be used to precisely estimate train-length in feet due to variations in cars' lengths. According to our review of the data, relevant documentation, and conversations with staff responsible for the data, we determined these data were sufficiently reliable to describe what is known about changes in freight train-length over time.

In addition, we reviewed relevant statutes, regulations, our prior reports, and documentation of federal agencies' actions and plans and interviewed a variety of stakeholders. Specifically, we reviewed documents and interviewed officials from federal agencies—including FRA, NTSB, and the Surface Transportation Board (STB)[7]—and a variety of other relevant stakeholders, including officials from national associations representing railroad employee unions, shippers, cities and towns, emergency managers, and emergency responders. We also reviewed relevant studies and interviewed academic researchers and other experts and individuals knowledgeable about freight train

[5]More specifically, two Class I railroads provided data on average train-length for at least 10 years, 2008 through 2017 and 2004 through 2017, respectively. Three Class I railroads provided average train lengths for 4 calendar years or less; however, one of these railroads provided data in a format that was not easily comparable with the others. Two Class I railroads declined to provide information on average train length over time.

[6]AAR is the trade association for the largest railroads in the United States and publishes a variety of railroad industry and economic reports, such as the annual publications *Freight Commodity Statistics* and *Railroad Facts*, and trend reports such as *Railroad Ten-Year Trends*. AAR's data are based upon public information that Class I railroads submit to the Surface Transportation Board. For example, every Class I railroad operating in the United States is required to submit an annual report (R-1) that includes a variety of information such as data on freight car-miles (a way to measure the movement of various types of freight car equipment a distance of 1 mile), train-miles (a movement of a train the distance of 1 mile), and ton-miles (a representation of the number of tons of revenue and non-revenue freight moved 1 mile in a train). 49 U.S.C. § 11145 and 49 C.F.R. § 1241.11.

[7]STB is an independent federal agency that regulates the freight railroad industry from an economic standpoint, including railroad rate reasonableness, railroad service and mergers, new rail-line construction, and associated environmental analysis.

operations, including officials from Canada's rail safety agencies[8] and representatives from companies that manufacture braking equipment for the rail industry. In addition, we selected a non-generalizable sample of five states in five of FRA's eight geographic regions, based upon a variety of factors, including locations where Class I railroads are known to operate longer trains, grade-crossing complaints, and variation in FRA region and geographic location. Based on these criteria, we selected the following states: Florida, Illinois, Ohio, Texas, and Washington. We reviewed documents and interviewed relevant stakeholders from all of these states, including state-level transportation and emergency management officials, state rail-safety inspectors,[9] and local officials, including emergency responders.

We identified standards for generally accepted research practices[10] and good practices for risk management.[11] We also identified best practices for strategic planning[12] and applied relevant federal standards for internal control that are key to helping agencies achieve their missions and desired results.[13] We evaluated FRA's efforts to assess safety risks of longer trains using these standards and selected strategic planning, research, and risk management practices from our prior work.

[8]More specifically, we spoke with officials from Transport Canada, which is responsible for transportation policies and programs in Canada that promote safe, secure, efficient, and environmentally responsible transportation, and the Transportation Safety Board of Canada, which is an independent agency that advances transportation safety by investigating occurrences in the marine, pipeline, rail, and air modes of transportation.

[9]The Railroad Safety Act of 1970 authorized states to work in partnership with the FRA to enforce federal railroad-safety regulations. Pub. L. No. 91-458, §§ 206 and 207, 84 Stat. 971, 972.

[10]We previously identified generally accepted research standards that are relevant for sound, complete studies. For our purposes, we determined that the standards related to presentation of results were relevant for our evaluation of FRA's actions. See GAO, *Defense Transportation: Study Limitations Raise Questions about the Adequacy and Completeness of the Mobility Capabilities Study and Report,* GAO-06-938 (Washington, D.C.: Sept. 20, 2006).

[11]GAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, GAO-17-63 (Washington, D.C.: Dec. 1, 2016).

[12]GAO, *Managing for Results: Critical Issues for Improving Federal Agencies' Strategic Plans*, GAO/GGD-97-180 (Washington, D.C.: Sept.16, 1997).

[13]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

We conducted this performance audit from February 2018 to May 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The U.S. Freight Rail System

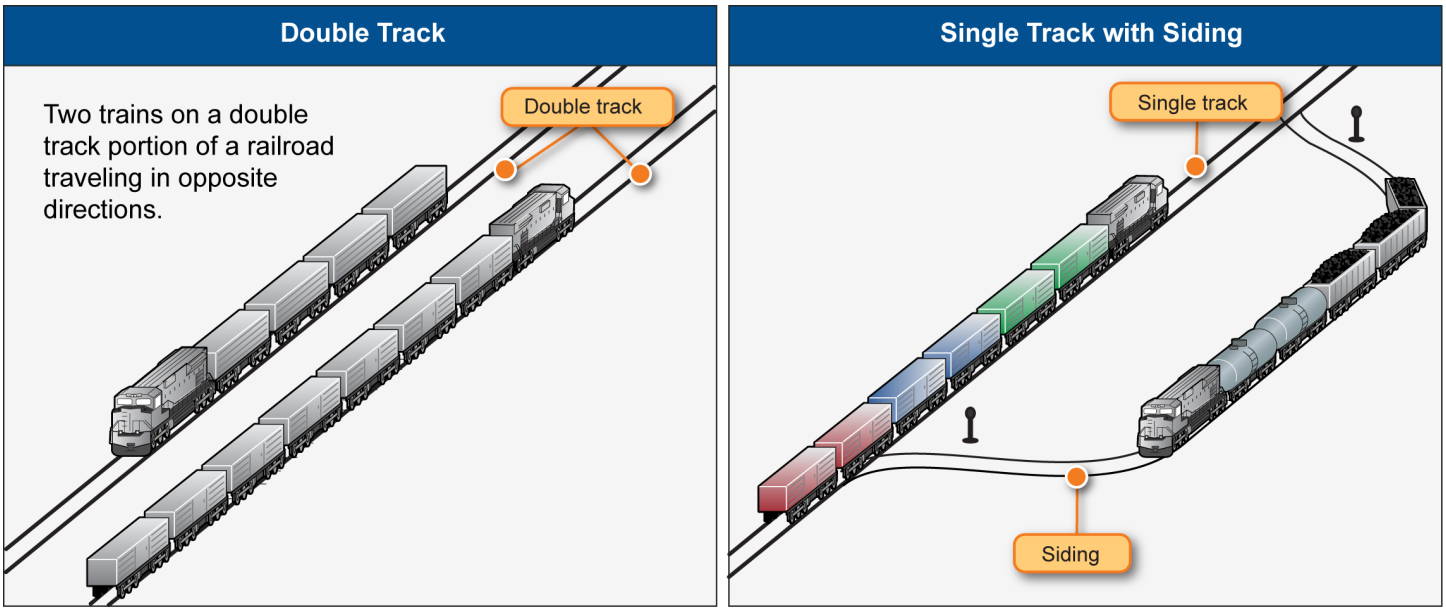
The U.S. freight rail network is a private industry that moves about 40 percent of U.S. freight across about 140,000 miles of track. Freight railroads are responsible for the safety of their trains, tracks, and personnel. These railroads rely on their revenues for funding to perform track inspections and maintenance. Close to 600 freight railroads operate in the United States, and they are divided into three classes according to revenues. The seven Class I freight railroads, those with approximately $447.6 million or more in annual revenue over 3 consecutive years, account for more than 90 percent of the annual revenues of the railroad-freight industry and employ 90 percent of railroad employees. Class I freight railroads move freight over long-haul routes and face competition from each other and from other freight-shipping modes, such as trucks and barges. Class II and III railroads tend to operate over much smaller geographic areas than Class I railroads and employ fewer people.[14]

Trains operate on different types of train tracks, including main line tracks—the primary rail arteries trains use to travel—and sidings, which are primarily auxiliary tracks for trains to pass one another. Trains can be stored, sorted, and assembled in railyards. Railroads use main line and sidings to enable trains to enter and leave the yard. Outside railyards, some sections of main line track have sidings that lead to a parallel set of rails to allow trains to pass one another. In addition, some portions of main line track consist of two or more parallel sets of track to allow trains

[14]At present, Class I railroad carriers include those having annual carrier operating revenues of approximately $447.6 million or more (as noted earlier). Class II railroad carriers are those having annual carrier operating revenues of less than $447.6 million but in excess of approximately $35.8 million. Class III railroad carriers are those having annual carrier operating revenues of $35.8 million or less. 49 U.S.C. § 20102(1) and 49 C.F.R. § 1201-1.

to pass one another or travel in opposite directions. See figure 1 for an illustration of different track types and siding.

Figure 1: Track Types and Siding



Source: GAO. | GAO-19-443

Freight Train Operations

Train Makeup and Handling

Train makeup refers to the placement of individual railcars that make up a train. A typical train consists of a locomotive—the power and control unit where the train operator sits at the front of the train—followed by connected railcars. The lead locomotive pulls the train and provides control for other functions, including braking. Freight trains carry a variety of freight using different types of railcars that vary in capacity, length, and weight. When assembling a train, railroads consider a variety of factors—such as each car's weight, length, freight, and whether it is loaded or empty—when determining its position in the train. Train make up is also dependent on external conditions, such as variations in terrain and weather conditions. Railroads can place radio-controlled locomotives, called distributed power (DP) units, throughout trains to spread out pulling and pushing power, which we discuss in more detail below.

Proper train makeup is critical for ensuring a train is able to effectively negotiate track and prevent derailment, according to FRA. Improperly

assembled trains are more susceptible to derailment, in part because of vertical, longitudinal, and lateral forces throughout the train—also known as "in-train" forces—that can affect the stability of a train on its tracks, depending on a variety of factors, including the train's speed and terrain. For example, excessive "in-train" forces can cause a long, heavy train to pull apart or climb off the track upon a change of grade (e.g., going up or down hills) or when the train enters a curve.[15]

"Unit trains"—which carry a single commodity, such as coal or oil, to one destination—experience in-train forces that are easier for railroads to model and engineers to predict because the railcars are generally uniform in size and weight. In comparison, determining train makeup is more complex in mixed freight trains, which can experience more unpredictable in-train forces resulting from railcars of different weights, lengths, and freight (e.g., bulk goods such as grain and coal, consumer goods such as automobiles, or hazardous materials). For example, if a train is assembled in a manner in which empty railcars alternate with loaded, heavy railcars, braking can create compression at the couplers and cause "buckling"—when an empty train car is compressed between heavier railcars and derails from the train tracks.[16]

Braking and Distributed Power

Freight trains in the United States utilize air-braking systems to control speed and stop. A conventional air-braking system is controlled by an air pressure signal from the leading locomotive, which sends a signal through the train to engage brakes. Because each railcar receives this signal sequentially, it takes multiple seconds for railcars at the end of the train to receive the air pressure signal and begin braking, depending on the train's length. The application of air brakes generates in-train forces, as railcars at the front of the train that have applied brakes will be pushed by railcars further back that have not yet received the air signal.

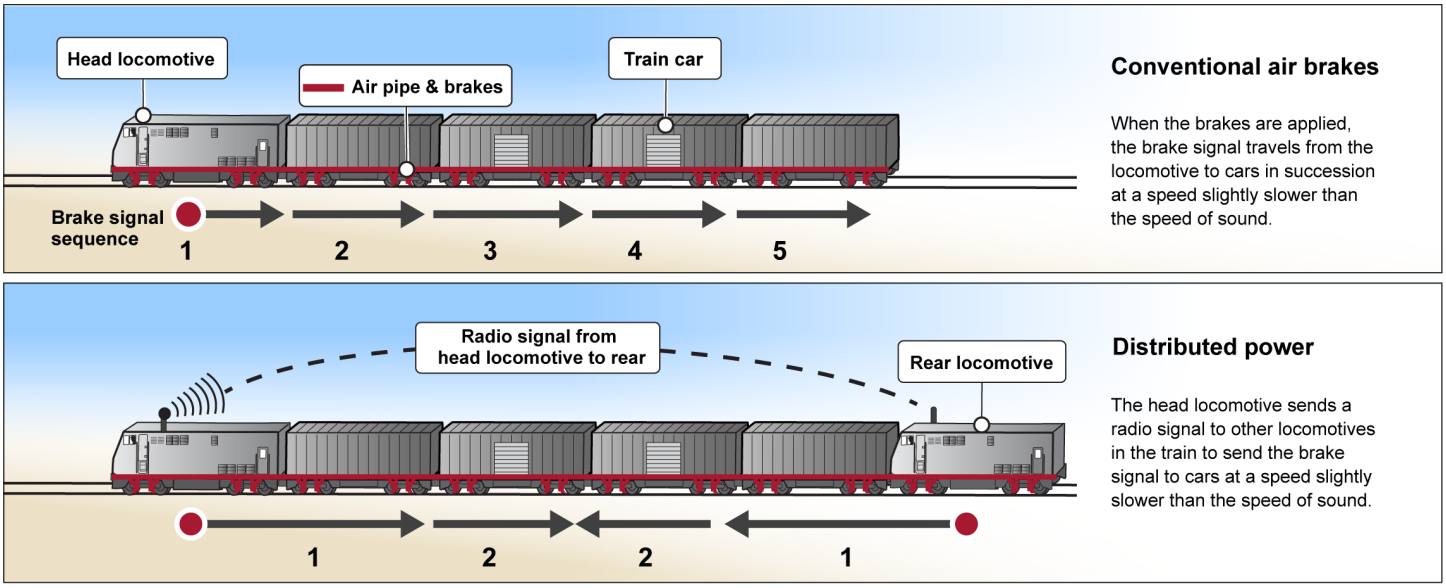
Other technologies, including two-way end-of-train devices and DP, are frequently used by U.S. railroads in conjunction with conventional brakes

[15]According to FRA, in-train forces include train resistance (which is the force of grade and speed changes, curves, and rolling resistance); force at the coupler (which is the connection that joins railcars); braking; and slack between railcars (which is the distance one railcar can move independently of the railcars ahead and behind it). See FRA, *Safe Placement of Train Cars: A Report* (June 2005).

[16]FRA and AAR have both issued non-binding guidance on train makeup. See FRA, *Safe Placement of Train Cars: A Report* (June 2005) and AAR Research and Test Department, *Train Makeup Manual Report No. R-802* (January 1992).

to provide improved braking performance or other benefits. End-of-train devices measure brake pressure and transmit this information via radio signal to the front of the train. An end-of train-device can also engage air brakes at the rear end of a train in an emergency to decrease the time required to apply the brakes on all cars.[17] As previously mentioned, railroads can also place radio-controlled locomotives, called DP units, throughout trains to spread out pulling and pushing power and improve braking. For example, engineers can engage a DP locomotive's air brakes at the same time as a leading locomotive to decrease the time needed to activate brakes throughout the train. (See fig. 2.) Engineers can also use a locomotive's dynamic brake system, which uses traction generated by the engine, to slow a train.[18]

Figure 2: Brake Signals on Trains with Conventional Air Brakes and Distributed Power



Source: GAO analysis of information from the Department of Transportation (DOT). | GAO-19-443

[17]FRA regulations address situations where radio communication is lost between an end-of-train device and the front of a train. Federal regulations require that if a radio signal is lost for more than 16 minutes and 30 seconds between the lead locomotive and end-of-train device, the grade trains may traverse is limited and trains may travel no more than 30 miles per hour until the signal returns. 49 C.F.R. § 232.407(g).

[18]Dynamic brakes cannot be used as a substitute for air brakes. 49 C.F.R. § 232.109(j)(1).

While most railroads employ conventional brakes, railroads can also employ electronically controlled pneumatic brakes—which provide an electronic brake signal instantaneously throughout a train—allowing railcars to brake faster than with conventional air brakes. As we previously reported, electronically controlled pneumatic brakes reduce the in-train forces that occur during braking when individual cars push and pull against one another.[19]

Train Crews

Freight trains in the United States generally operate with two crew members—the conductor and the engineer. The conductor is responsible for the train, freight, and crew. The engineer operates the locomotive, including application of air brakes, dynamic brakes, and any radio-controlled DP locomotives. Train crews use hand-held radios to communicate when they are working in different parts of the train. For example, if the crew detects a train maintenance issue, the conductor may need to leave the locomotive and walk the length of the train to address the problem. In these situations, the conductor may use a hand-held radio to communicate.

The Role of Federal Agencies and States

FRA and States

The U.S. Department of Transportation (DOT) is responsible for ensuring the safety of the transportation system. Within DOT, FRA is the primary federal agency responsible for formulating railroad safety policies and regulations and for monitoring and enforcing railroads' compliance with requirements. FRA's mission is to enable the safe, reliable, and efficient movement of people and goods.

FRA provides regulatory oversight of the safety of U.S. railroads, including both passenger and freight. FRA issues and enforces safety regulations including requirements governing track, signal, and train control systems, grade-crossing warning systems, mechanical equipment such as locomotives and railcars, and railroad-operating practices. In developing most of its regulations, FRA seeks input from the railroad

[19]For more information, see GAO, *Train Braking: DOT's Rulemaking on Electronically Controlled Pneumatic Brakes Could Benefit from Additional Data and Transparency,* GAO-17-122 (Washington, D.C.: Oct. 12, 2016).

industry and other organizations through its Railroad Safety Advisory Committee.[20]

FRA provides oversight of railroad safety through a variety of activities, including periodic inspections and enforcement actions. FRA has safety inspectors and specialists in eight regional offices that are primarily responsible for the enforcement of federal laws and regulations related to railroad safety. FRA conducts inspections of railroads to monitor compliance with safety regulations, such as those governing the transport of hazardous materials, among other issues. In addition, 31 states conduct inspections for compliance with federal safety regulations. FRA trains state inspectors to enable them to conduct inspections according to FRA's standards.[21]

In addition to these activities, FRA conducts other types of safety oversight to reduce train accidents, such as analyzing railroad safety data, investigating accidents, and reviewing complaints. FRA also funds research and development to support its safety oversight. FRA's Office of Research, Development, and Technology conducts research to understand railroad safety risks and improve safety. This work contributes information used to inform FRA's development of regulations, standards, and best practices.

[20]To adopt a participatory approach to rulemaking, in 1996, FRA first established the Railroad Safety Advisory Committee, which is designed to bring together all segments of the rail community to provide advice and recommendations to FRA on railroad safety issues. The committee includes representatives from railroads, labor, shippers, industry associations, and other government agencies. The committee provides recommendations to FRA on issuing and updating regulations and identifies non-regulatory approaches to improve safety. According to FRA, the full committee last met in April 2019. In addition, FRA added it fully complies with the Administrative Procedure Act requirements for notice and comment from the public, and benefit-cost, small business, and other analyses.

[21]In 2013, we examined how FRA, the states, and railroads work together to ensure rail safety and identified any challenges to FRA's safety framework. We found that FRA faced several rail safety challenges, including adjusting to changing rail traffic flows and ensuring it had enough inspectors for its current and future oversight workload. We recommended that FRA develop a plan for issuing its risk reduction rule—which will require Class I railroads to identify and mitigate risks through risk reduction programs—and further, to review and approve railroads' risk reduction programs once completed. These programs are designed to provide a comprehensive process for the application of criteria and techniques to help railroads proactively manage safety. FRA has implemented this recommendation; however its risk reduction rule has not yet been finalized. See *GAO, Rail Safety: Improved Human Capital Planning Could Address Emerging Safety Oversight Challenges*, GAO-14-85 (Washington, D.C.: Dec. 9, 2013) and 80 Fed. Reg. 10950 (Feb. 27, 2015).

Other Federal Agencies

Other federal agencies also have roles in overseeing freight railroads, such as through promoting safety or regulating railroad industry economics. For example, NTSB is an independent federal agency that produces safety studies and investigates transportation-related accidents across all transportation modes to determine probable causes, identify safety issues, and make recommendations to prevent recurrences. STB oversees significant rail-service matters and resolves rate and service disputes between railroads and their customers, known as "shippers." Class I railroads report data to STB on the amount and type of freight they transport. STB produces and releases statistical data derived from the railroad's submitted data.

Freight Train Length Has Increased, and Railroads Identified Advantages to Operating Longer Trains

According to officials from all seven Class I freight railroads and representatives from AAR, FRA, STB, and other stakeholders we interviewed, freight train-length has increased in recent years; however, the data are limited. According to data that two Class I railroads provided to us, their average train length increased over the 10-year period of 2008 through 2017 by about 1,500 feet for one railroad (from about 6,000 to 7,500 feet, or up to about 1.4 miles) and about 1,200 feet for the other railroad (from about 4,900 to 6,100 feet, or up to about 1.2 miles). These data represent an increase in the average length of a train of about 25 percent for both railroads.[22] Two additional Class I railroads reported average train lengths between about 5,800 and 6,600 feet for the year 2017.[23] However, we were not able to verify increases more broadly because FRA, STB, and AAR do not collect comprehensive data on train-length in feet, and while such data are collected by Class I railroads, they are not publicly available. Officials from two Class I railroads stated that operating longer trains is not a new practice, and one official noted that the railroad has been operating trains in excess of 10,000 feet in selected rail corridors for almost 30 years. Officials from AAR added that increases in train length over time have likely been gradual.

[22]Although we received data describing average train length from five of seven Class I railroads, we are reporting data for the two Class I railroads that provided data with a sufficient number of years to describe a trend. These two railroads represented about 6 percent of all Class I's revenue-ton-miles in 2017. Each Class I railroad is unique, and the information provided by these railroads over time is used for illustrative purposes only and is not representative of all Class I railroads.

[23]These two railroads represented about half of all Class I's revenue-ton-miles in 2017. While these data do not describe trends over time, they provide information on average train-length in 2017 for additional Class I railroads.

While two Class I railroads provided data on average freight train-length over time, officials from each of the seven Class I railroads stated that they operate longer trains. Railroad officials said they operate these trains in certain rail corridors that have the capacity to accommodate longer trains, and not over their entire rail networks. For example, officials from one Class I railroad said they are running on a daily basis a 12,000-foot train—which is about 2.3 miles long—and another reported that twice weekly it operates a 16,000-foot train—which is about 3 miles long—on a route linking the mid-west to the west coast. Both of these Class I railroads noted that longer trains such as these are a small percentage of the trains they operate. More specifically, one of these railroads reported that over the previous 24 months, about 1 percent of its train-miles were traveled by trains over 10,000 feet long, and the other reported that about 2 percent of its current train-miles were traveled by trains over 10,000 feet long.[24]

Other data describing the average number of railcars per train and average weight of trains indicate an overall increase over the past 10 years. However, these measures are not proxies for freight train-length since the length and weight of railcars can vary significantly depending on their design and freight.[25] Class I railroads are required to report data, such as the freight car-miles, to STB annually,[26] and AAR aggregates and makes this information publicly available in various publications.[27] We

[24]These two Class I railroads reported that trains between 6,000 and 8,000 feet in length comprised the majority of their train-miles traveled (about 67 percent and 55 percent, respectively).

[25]For example, according to one Class I railroad, their boxcars (i.e., covered railcars with sliding doors that carry a wide range of products) may range in length from 50 feet to 86 feet and can carry from 70 to 100 tons apiece. In contrast, their hoppers (i.e., covered or uncovered railcars into which bulk commodities are loaded from the top) range in length from 39 feet to 65 feet and vary in capacity from 70 to 110 tons. As a result, a 100-car train composed of “standard” box cars (e.g., 50-foot cars) would be shorter than another 100-car train composed of “jumbo” hopper cars (e.g., 65-foot cars).

[26]49 U.S.C. § 11145 and 49 C.F.R § 1241.11. As previously mentioned, every Class I railroad operating in the United States is required to submit an annual report (R-1) to STB that includes a variety of information such as data on freight car-miles (a way to measure the movement of various types of freight car equipment a distance of 1 mile), train-miles (a movement of a train the distance of 1 mile), and ton-miles (a representation of the number of tons of revenue and non-revenue freight moved 1 mile in a transportation train).

[27]As previously mentioned, AAR publishes a variety of railroad industry and economic reports, such as the annual publications *Freight Commodity Statistics* and *Railroad Facts*, and trend reports such as *Railroad Ten-Year Trends*.

analyzed these data and found that the average number of railcars per freight train across all Class I railroads increased from 71.0 to 73.2 railcars per train (an increase of about 3 percent) from 2008 through 2017. Additionally, FRA and some Class I railroad officials stated that railroads operate freight trains that have more than twice this average number of railcars—including trains with 150 railcars or more. Similarly, the average train weight increased from about 5,978 tons to 6,577 tons per train (an increase of about 10 percent) from 2008 through 2017.

Class I railroad officials said that there are advantages to operating longer freight trains in some rail corridors and that operating longer trains is part of strategic planning for many railroads for a variety of reasons. Officials from all Class I railroads stated that they operate longer trains in some rail corridors as a way to increase efficiencies, such as fuel efficiency, and decrease costs by reducing the number of train crew and other costs. Additionally, railroad officials said that running longer trains can mean that they do not need to operate as many trains—officials from six Class I railroads specifically indicated they are operating fewer shorter trains as a result of operating longer trains. Further, Class I railroad officials stated that market forces, such as competition from the trucking industry, create an incentive for them to increase efficiency. Class I railroad officials also stated that the use of certain technologies, such as DP locomotives, enables them to operate longer trains more safely. Other Class I railroad officials attributed their increased usage of longer trains to capital improvements on railroad tracks, such as lengthening the sidings to accommodate longer trains.

Stakeholders Identified Considerations for Safely Operating Longer Freight Trains and Potential Impacts on Communities

Considerations for Operating Longer Trains Include Train Makeup and Handling and Crew Training

Train Makeup and Handling

While the need for proper train makeup and handling are not unique to longer trains, it is particularly important for their safe operation, according to stakeholders we spoke with. As previously discussed, the length of each train and its makeup—the manner in which its cars and locomotives are arranged—can affect the forces involved on a moving train.[28] Stakeholders we spoke with said that the consequences of improper train makeup may be more pronounced in longer trains—especially in situations with extremes in track grade, curvature, or weather conditions—and may add to the challenges of operating longer trains. For example, FRA has investigated accidents in which it determined that train makeup and handling were the probable cause and contributing factors in train derailments of longer freight trains.[29] According to officials from FRA,

[28]See FRA, *Safe Placement of Train Cars: A Report* (June 2005).

[29]More specifically, one such derailment in Atlanta, Georgia in October 2017 involved a train with 197 railcars that was nearly 2.4 miles long. In other examples, FRA investigations have identified problems with couplers—the connection that joins railcars—associated with long, heavy trains traveling through undulating terrain. According to FRA, train makeup accidents are not new to the industry or to longer trains. Further, FRA stated that train makeup accidents occur on all trains and all train lengths and that most Class I railroads use computer programs that evaluate an individual train's car makeup and warn of placement errors.

NTSB, railroad employee unions, and other stakeholders, longer mixed-freight trains may be more difficult to handle than unit trains in certain circumstances due to variations in car length and weight and the extent to which additional DP locomotives are employed.

Stakeholders noted that placing additional DP locomotives within a train can improve train handling and prevent train separations and derailments. Stakeholders added that using DP can also help improve air brake performance and reduce braking response time, as previously discussed. In addition, according to stakeholders, use of properly positioned DP locomotives can improve radio communication between the lead locomotive and rear DP locomotives on longer trains.[30] Union representatives added that in their view, the safest train-braking operations are when DP locomotives are used in conjunction with electronically controlled pneumatic brakes. According to representatives from AAR and Class I railroads, however, freight railroads have faced challenges with these braking systems, including reliability issues, as we have noted in a previous report.[31]

While there are no comprehensive federal regulations that govern train makeup, including use of DP locomotives, representatives of Class I railroads told us they consider a variety of factors when determining train makeup to ensure safe operation of all of their trains, including tonnage, train-length, and terrain.[32] According to one railroad, using software to determine train makeup and predict train handling needs is an industry standard and critical best practice. Another railroad told us they use

[30]Union officials said that these communications can fail when longer trains travel around curves, over the tops of mountains, or through terrain with dense vegetation. Representatives from Class I railroads mentioned use of communication transmitters or repeaters to increase signal strength and improve the radio communication between the head and end of a train. A radio repeater is a combination of a radio receiver and a radio transmitter that receives a weak or low-level signal and retransmits it at a higher level or higher power, so that the signal can cover longer distances without degradation. As previously mentioned, pursuant to 49 C.F.R. § 232.407(g), if an end-of-train device loses its radio communication signal with the front of the train for more than 16 minutes and 30 seconds and, as a result, is unable to initiate an emergency brake application, the engineer is notified, and the train's speed is limited to 30 miles per hour.

[31]GAO-17-122.

[32]According to FRA, while there are no comprehensive requirements that govern train makeup, FRA enforces regulations set forth by the Pipeline and Hazardous Materials Safety Administration that govern the placement of placarded hazardous material cars in a train. 49 C.F.R. § 174.85.

computer simulations to develop rules for train makeup in order to operate longer and heavier trains. Some railroads told us they impose length and weight restrictions on specific routes to ensure safe train operation and manage corridor capacity. Union representatives and rail experts we spoke with told us that in their view, railroads do not always properly assemble their longer trains, for example placing heavy railcars behind lighter railcars, a practice that can increase the likelihood of derailment. These stakeholders also said that railroads do not always use DP with longer trains, which experts attributed to the extra cost of deploying additional locomotives. We did not independently verify how the railroads we spoke with assemble or operate longer trains.

Training Crews to Operate Longer Trains

Stakeholders we interviewed said that it is essential that crews are properly trained to operate longer freight trains. FRA regulations require railroads to train and certify their train crews.[33] More specifically, FRA requires qualified locomotive engineers to demonstrate proficiency in operating trains in the most demanding type of service they may be permitted to perform, which includes operating longer trains.[34] Railroads are required to conduct annual performance evaluations of engineers to ensure that they can safely operate trains according to federal railroad safety requirements.[35] Representatives of Class I railroads told us they train their crews on trains and simulators with various routes, scenarios, and train lengths. However, union representatives said that some railroads do not provide sufficient training for crews to operate longer trains, and that some locomotive engineers and conductors lack the necessary training and experience to handle longer trains, a situation that can be challenging even for properly trained crew. As discussed later, FRA is planning to review this issue when it performs planned audits of Class I railroads' training programs.

[33]49 C.F.R. Parts 240, 242, and 243.

[34]49 C.F.R. § 240.213. FRA regulations require that each railroad shall determine that the person has the knowledge and skills to safely operate a locomotive or train in the most demanding class or type of service that the person will be permitted to perform. Specific topics for training programs include personal safety, railroad operating rules, handling trains over the railroad's territory, federal regulations, and operating the different train types normally used by the railroad.

[35]49 C.F.R. § 240.129. In addition, FRA regulations require that FRA review new and materially modified railroad-crew-training programs and also meet with railroads to discuss strategies to reduce instances of poor safety conduct by train crews. See 49 C.F.R. § 240.103 and 49 C.F.R. § 240.309, respectively. According to FRA, the agency may audit training programs and require railroads to update deficient training programs to comply with regulations.

Stakeholders we interviewed identified additional challenges for crews when operating longer freight trains related to crew members' fatigue. For example, according to FRA, union representatives, and other stakeholders, a longer train may require crew members to walk a long distance if the train stops unexpectedly. For example, when there is a mechanical or other problem that causes a train to stop, the conductor may have to walk from the lead locomotive to the problem area and back again. This could mean walking 4 miles to the end and back on a 2-mile-long train. Also, according to FRA officials, as with any train that is left unattended, the crew must apply a sufficient number of handbrakes to prevent unintended movement. With longer and heavier trains, railroads may require additional handbrakes to be applied. According to union representatives, such physically demanding tasks can increase crew fatigue.

Longer Trains May Impact Grade Crossings in Communities

Stakeholders we interviewed expressed divergent views about whether longer trains may increase or decrease blockages at grade crossings. Our prior work has noted a connection between the volume of freight rail traffic and the potential for grade-crossing blockages to increase.[36] In 2014, we found that trends in freight flows, if they continue as expected, may exacerbate congestion issues in communities, particularly along certain corridors.[37] FRA officials told us that complaints about blocked highway-rail grade crossings have increased in recent years. They noted that blocked crossings are a local concern and it is not clear the extent to which longer freight trains are contributing to increases in reporting about such blockages. According to FRA, trains sometimes block crossings for a limited time or for hours if an accident or mechanical problem occurs. They noted that such blockages can be created by trains of any length and that in their experience, railroads prioritize movement of longer trains, making it less likely that such trains would be responsible for prolonged

[36]As we previously reported, the amount of time that highway-rail grade crossings are blocked depends on a number of factors and is typically a function of the number, speed, and length of trains. See GAO-16-274.

[37]We found a key impact of increasing freight flows is congestion at highway-rail grade crossings, where road traffic must wait to cross the tracks when trains are passing. We recommended that DOT clarify the federal role for mitigating local freight-related congestion in the National Freight Strategic Plan, including a strategy for improving needed data. According to DOT officials, they are continuing work on the National Freight Strategic Plan and believe it will be released in 2019. See GAO, *Freight Transportation: Developing National Strategy Would Benefit from Added Focus on Community Congestion Impacts,* GAO-14-740 (Washington, D.C.: Sept. 19, 2014).

blockages of crossings. Furthermore, officials from FRA and Class I railroads and others we spoke with pointed out that longer trains may decrease the frequency of blocked crossings, as railroads may run fewer trains.

In contrast, officials from the National League of Cities, as well as state and local officials we spoke with, expressed concerns over increased frequency of longer trains and their impact on grade crossing safety.[38] Although they also acknowledged that trains of any length can block grade crossings, they raised concerns that longer trains prolong the duration of a blockage and can block more crossings concurrently, making it harder for vehicles to find an alternate route around the train. Consequently, these stakeholders are concerned that longer trains create increased delays for emergency responders and increase the likelihood of unsafe behavior among motorists and pedestrians, as outlined below.

- *Delayed emergency response*. According to national, state, and local officials we interviewed, longer trains pose concerns about the potential for emergency response delays if responders encounter a train blocking one or more crossings and cannot quickly find an alternate route around it. (See fig. 3.) For example, officials in Mount Victory, Ohio, reported that 22 freight trains travel through their town daily, including a 16,000-feet train, which is nearly 3 miles long. This train blocks 4-to-5 grade crossings concurrently, which increases the time to access parts of the town, according to local officials. Our prior work has found that blocked highway-railroad grade crossings can have significant impacts on emergency response time and outcomes.[39] For example, we reported an instance of a fire that destroyed a house while train traffic blocked the only two crossings in the town and prevented fire crews from responding in time. In another example, a local official in Texas said that one Class I railroad assembles trains and conducts brake checks on the main line tracks because the trains are too long to fit into sidings and railyards. Executing such procedures on mainline track has blocked grade

[38]The National League of Cities is a membership organization that represents the interests of 19,000 cities, towns, and villages across the United States, as well as professionals working in local government.

[39]In our report, we recommended that DOT clarify the federal role for mitigating local freight-related congestion in the National Freight Strategic Plan, including a strategy for improving needed data. DOT has not yet implemented this recommendation. See GAO-14-740.

crossings for up to several hours and poses safety challenges for surrounding communities, according to this local official. As a result of situations like these, communities are looking for ways to mitigate delays in emergency services when emergency vehicles must find ways around blocked grade crossings. For instance, some local officials in Washington and Ohio said they have revised their emergency response plans to avoid grade crossings that are likely to be blocked.

Figure 3: Emergency Vehicle Blocked by Freight Train



Source: National Industrial Transportation League – Photo by Bruce Ridley. | GAO-19-443

- *Motorist and pedestrian behavior*. Stakeholders we spoke with expressed concerns that longer trains may increase the likelihood of unsafe behavior among motorists and pedestrians. For example, fatalities can occur when motorists or pedestrians engage in risky behavior such as trying to make it across the tracks before an approaching train reaches the crossing. Moreover, pedestrians have been known to crawl over, through, or under stopped trains (see fig. 4). For example, local officials in Ohio and Texas told us that they have witnessed children crawling through stopped trains to get to school. Research sponsored by FRA has identified driver behavior as the main cause of highway-rail grade crossing collisions, but other

factors such as train and traffic volume can contribute to the risk of a crash occurring.[40]

Figure 4: Individuals Climbing through Stopped Train



Source: Federal Railroad Administration. | GAO-19-443

Although there are no current federal regulations that directly address blocked crossings or limit the amount of time trains can block grade crossings, some states and localities have attempted to address this issue.[41] For example, some states and localities have passed laws

[40]In our 2018 report on grade crossings, state officials we spoke with explained that drivers may become impatient waiting at a grade crossing and decide to go around the gates, an action that may increase the likelihood of collisions. Crashes at highway-rail grade crossings are one of the leading causes of railroad-related deaths. According to FRA data, in 2017 there were more than 2,100 crashes resulting in 273 fatalities. Over 70 percent of fatal railroad crashes in 2017 took place at grade crossings with gates. See GAO, *Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges*. GAO-19-80 (Washington, D.C.: Nov. 8, 2018).

[41]While there are no current federal regulations that directly address blocked crossings, FRA stated that 49 C.F.R. § 234.209 prohibits standing trains, locomotives, and other railroad equipment from unnecessarily activating grade crossing warning devices. According to FRA, this is not limited to standing trains, locomotives, and other railroad equipment that block vehicular access to the crossing.

limiting the duration of blocked crossings and proposed fines for railroads,[42] but state and local officials and other stakeholders we spoke with said that federal law preempts such efforts.[43] Other states and local communities have attempted to address blocked crossings through studies and communication with federal agencies and railroads, with mixed success. For example, the Texas Department of Transportation has undertaken mobility studies for the towns of El Paso and Laredo to identify options to address blocked crossings, such as constructing bridges or underpasses. According to officials with the Texas Department of Transportation, these studies identified alternatives that may help alleviate some of the vehicular/rail conflicts if they were implemented; however, the implementation of alternatives for any potential projects are constrained by the availability of funds.[44] In other examples, local officials from Ohio and Illinois told us they have contacted Class I railroads and FRA to find solutions when idle trains lead to blocked crossings, especially when emergency access is a concern but continue to face challenges. Class I railroads and FRA officials said they work with local communities to find solutions to these issues.

[42]State laws on blocked grade crossings vary. According to FRA, 35 states and Washington, D.C. have laws addressing blocked crossings by on-track railroad equipment. More specifically, 7 states have no time limit; 14 states and Washington, D.C. allow no longer than 5 minutes; 10 states allow no more than 10 minutes; 3 states allow no more than 15 minutes; and 1 state allows for no more than 20 minutes for a train to block a crossing.

[43]In some specific cases, courts have found state and local legal actions are preempted under the Interstate Commerce Commission Termination Act and federal railroad safety statutes. For example, in 2008, the Illinois State Supreme Court struck down a state law regulating the amount of time trains can block highway-rail grade crossings finding that the state law was preempted by federal law. *Eagle Marine Industries, Inc. v. Union Pacific R. Co. 882 N.E.2d 522 (Ill. 2008)*. In 2001, a federal appeals court also ruled that a state law on blocked crossings could not be enforced because it was preempted by federal law. *Friberg v. Kansas City S. Ry. Co.*, 267 F.3d 439, 443 (5th Cir. 2001).

[44]We previously reported that DOT grants to states can be used to improve safety at grade crossings but eliminating crossings completely–for example by constructing a bridge or underpass—is uncommon compared to other grade-crossing safety projects. See GAO-19-80.

Additionally, state and local officials noted that they do not have access to information on the length of trains that travel through their communities.[45] Some added that freight railroads are not required to provide such data and that local efforts to gather this information, such as through videotaping train movements and analyzing data, are costly. This circumstance makes it challenging for state and local officials to assess the extent to which longer trains may or may not be contributing to blocked crossings.

FRA Is Studying Operational Risks of Longer Trains but Lacks a Strategy for Sharing Research Results and Is Not Fully Assessing Community Risks

FRA Is Studying Operational Risks of Longer Freight Trains

In the fall of 2017, FRA began a study to understand operational risks of long freight trains.[46] The study is examining issues related to train makeup and handling, including the use of DP locomotives, crew training and fatigue, and braking performance for longer trains. The study intends to identify strategies to reduce any risks identified. According to FRA, as the railroad industry has increased the length of freight trains, past accepted practices for train makeup and handling may not be appropriate

[45]In 2016, we reviewed blockage of highway-rail grade crossings in border communities. We found that DOT's data improvement efforts could better equip state and local governments to define the extent of blocked highway-rail grade crossings in communities nationwide, including at rail border communities. See GAO, *U.S. Border Communities: Ongoing DOT Efforts Could Help Address Impacts of International Freight Rail,* GAO-16-274 (Washington, D.C.: Jan. 28, 2016).

[46]Although FRA regulations do not define a long train, for the purposes of the study, FRA defines a "very long train" as a freight train greater than 150 railcars. According to FRA, this definition was chosen because current performance standards for air brakes are based upon a 150-railcar train. See 49 C.F.R. § 232.103 (l) and AAR Standard S-469, "Performance Specification for Freight Brakes," which is incorporated by reference in the regulation.

for longer trains. For example, according to FRA, the current performance standard for air brakes was last updated in 1947 and based on tests for trains with up to 150 cars. FRA officials stated the study will conduct air brake tests to evaluate brake performance for trains with 150-to-250 railcars and use this data to conduct computer simulations of trains in a variety of configurations—for example, with and without DP and with DP locomotives at different locations throughout a train—to evaluate in-train forces. According to FRA officials, this information will help FRA determine whether rail safety issues exist for trains with over 150 railcars and if regulatory actions are necessary.

The study employs a two-phase approach that includes data analysis, literature review, computer simulations, and brake testing. FRA officials said the agency plans to complete the first phase of its study and issue a report by the end of 2020 and issue a report on the second phase by the end of 2021. Table 1, below, outlines specific tasks of the study by phase.

Table 1: Selected Tasks in the Federal Railroad Administration's (FRA) Study on Longer Freight Trains

Phase	Tasks
Phase I (2020 expected completion)	• Identify routes, frequency, operating practices, and potential risk factors for operating longer trains. • Review crew fatigue studies and analyze FRA accident data to understand causes of accidents, injuries, and fatalities (including human factors) for trains of more than 150 cars.[a] • Conduct a literature review on operations, experiences, and challenges of operating long trains in the United States and other countries, including providing information on new training programs to operate longer trains. • Conduct simulations with a variety of train lengths, track scenarios, train makeups (e.g., trains with and without distributed power), handling options, and other factors to understand how to minimize in-train forces.
Phase II (2021 expected completion)	• Test air brake performance for trains of 150–250 cars using air-brake test racks and field tests.

Source: GAO analysis of Federal Railroad Administration documents. | GAO-19-443

[a]For the purposes of FRA's study, a "very long train" is defined as a freight train greater than 150 cars. Neither industry standards nor federal rail safety regulations define a long train nor limit train length, according to FRA.

As we previously mentioned, FRA provides oversight of railroad safety through a variety of activities to ensure compliance with regulations, such as conducting inspections of railroad operations and reviewing and

approving new and materially modified railroad crew training programs. According to FRA officials, these activities address safety for all freight trains, including longer trains. In addition to these activities, FRA plans to begin new, more in-depth audits of Class I railroads' training programs on a systematic basis in 2019 to determine whether engineers are being adequately trained to operate longer trains and perform other types of demanding service. According to FRA, these audits will determine whether locomotive engineer certification programs are in compliance with federal rail safety regulations. For example, federal regulations require that railroads provide training to their engineers—through classroom lessons and in trains or simulators—on the most demanding type of service they may be called upon to perform.[47] According to FRA officials, this would include operation of longer freight trains in challenging terrain. FRA plans to audit the training programs of three Class I railroads by the end of 2019, selected based upon safety risk factors, with additional audits of other railroads planned for the following year. Once the audits are complete, FRA plans to discuss its findings with each audited railroad and make recommendations for improvements, as needed.

FRA Lacks a Strategy for Sharing the Results of Its Study on Longer Trains

While FRA's study to assess operational safety risks of longer trains is under way, the agency lacks a current, documented strategy for how it will use and share the results of its research with relevant stakeholders. According to FRA officials, after internal review and approval, the agency routinely shares its research results at conferences and on its website.[48] However, FRA's strategic plan for research and development, which outlined how the agency shares research results and engages with internal and external stakeholders in support of FRA's rail safety mission, expired in 2017.[49] More specifically, this plan outlined key internal and external stakeholders and their roles—including labor and industry partners—and specific outreach strategies, such as holding periodic, public events to present FRA's research and development. This plan also stated that FRA's research provides the scientific and technological basis for its rulemaking and regulation enforcement and that effectively sharing

[47]49 C.F.R. § 240.127(b).

[48]For example, between January 1, 2018, and April 15, 2019, FRA posted on its website 80 technical reports and research results, according to FRA.

[49]FRA, *Research and Development Strategic Plan, FY2013-FY2017* (Washington, D.C.: May 2013).

the results of its studies increases the likelihood that its research will have "real world" impacts. According to FRA officials, the agency is currently updating its strategic plan for research and development, which will outline FRA's goals and objectives for its research, and expects to finalize the plan by the summer of 2019. FRA does not have any other documented policies in place for how it will use or disseminate the results of its study.

Federal internal control standards call for management to communicate quality information—using appropriate methods—both internally and externally in order to achieve an entity's objectives and respond to risks.[50] Further, our work on best practices for strategic planning has found that formulating specific strategies and linking them with goals and objectives is critical for agencies to achieve these goals and objectives.[51] In addition, we previously identified generally accepted research standards for sound studies, standards that include presentation of results.[52] These standards call for relevant stakeholders to be informed of research results and any recommendations upon completion of a study.

The Transportation Research Board—a part of the National Academies of Sciences, Engineering, and Medicine which provides research-based solutions to improve transportation, among other things—has found that organizations that develop processes and a systematic approach to implementing research are more effective and efficient at applying research results.[53] FRA's study is a first step for determining how, if at all, makeup and handling for longer trains as well as their crews' needs may differ from shorter trains. If study results are effectively shared with relevant stakeholders, then those best situated to act on the results may be more likely to do so. For example, FRA officials—who have rulemaking and enforcement authority—could identify and implement changes needed to improve the safety of longer train operations, such as by issuing relevant guidance, rulemaking, or other actions. Similarly, external stakeholders, such as Class I railroads and workers, would have

[50]GAO-14-704G.

[51]GAO/GGD-97-180.

[52]GAO-06-938.

[53]Transportation Research Board, *National Cooperative Highway Research Program Synthesis 461: Accelerating Implementation of Transportation Research Results* (Washington, D.C.: 2014).

the opportunity to use study results to inform their practices and policies, such as making changes to internal train-makeup rules or operators' training programs for longer trains. As FRA updates its strategic plan for research and development, formulating specific strategies for how it will share its research results with internal and external stakeholders would help to ensure FRA is in the best position to achieve its research goals and objectives in support of the agency's mission of enabling the safe, efficient, and reliable transportation of people and goods.

FRA Is Not Fully Assessing Community Impacts Related to Longer Trains

While FRA is taking steps to assess operational safety risks of longer trains through its study and other efforts, it is not assessing whether longer freight trains impact communities by blocking more grade crossings. Safety at grade crossings has been a longstanding issue in the United States, and according to stakeholders we spoke with, some of these issues may be exacerbated by longer trains. In 2006, as part of its report on the impacts of blocked grade crossings on emergency response services, FRA stated that future growth in rail and highway traffic will likely increase blocked crossings, and more recently FRA officials stated that this is still the case.[54] In addition, while collisions at grade crossings have declined over time, FRA also expects the risk of grade-crossing incidents to grow as both rail and highway traffic increase during the next decade. However, FRA officials also stated that there is no evidence that more blocked crossings results in more grade-crossing incidents. Further, according to FRA, the agency is not in a position to address community-specific public safety issues. We have previously reported that the amount of time that grade crossings are blocked depends on a number of factors and is typically a function of the number, speed, and length of trains.[55]

Although there are no federal regulations directly addressing blocked grade crossings, to gauge the extent of reported instances of blocked crossings, in early 2018, FRA began to track data on the location of blocked-crossing complaints from state rail-safety managers in nine states.[56] FRA officials stated they intend to use this data to identify

[54]FRA, *Impact of Blocked Highway/Rail Grade Crossings on Emergency Response Services* (August 2006).

[55]GAO-16-274.

[56]FRA is tracking this data to learn more about the locations of blocked crossings in each of the nine states. Specifically, it is placing a mark on a computerized map at the location of each blocked crossing complaint.

communities where frequently blocked grade crossings are reported and work with the railroads and communities for resolution. However, FRA officials said they do not plan to explore any potential impacts of longer trains on grade crossings in communities, as FRA officials have stated they do not believe that longer trains are having an impact on blocked crossings. For example, FRA does not plan to use any of the information gathered in its longer train study—which will include a sampling of the routes longer trains travel—to inform the agency's work on blocked crossings because FRA officials stated that they do not expect the study will yield relevant information. State and local officials we spoke with, as previously mentioned, expressed concerns about the potential for longer trains to increase the number of blocked grade crossings, causing delays for emergency responders and affecting the behavior of motorists and pedestrians.

Federal internal control standards state that effective use of information and communication are vital for an entity to achieve its objectives. These standards call for management to use quality information—relevant, reliable information that is current, complete, accurate, accessible, and timely—to achieve an agency's objectives and respond to risks. Further, we previously identified essential practices for agencies to help manage risks and identify opportunities that could impact the achievement of agencies' goals. These risk-management practices call on agencies to systematically identify risks and use the best information available to assess them.[57]

Community officials acknowledged that while they believe longer trains are making blocked crossings worse, they do not have access to information needed to confirm this observation. As previously discussed, some local communities continue to face challenges after reaching out to FRA and Class I railroads to find solutions to issues related to grade crossings. As these issues continue to evolve and FRA works to identify locations where blocked crossings are reported, working with railroads and local communities to identify any potential impacts of longer trains on grade crossings would help FRA to determine whether and how longer trains are affecting these communities and what could be done to address those impacts. In addition, it would allow FRA to determine whether it should take additional action to ensure that longer trains are operating

[57]GAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, GAO-17-63 (Washington, D.C.: Dec. 1, 2016).

safely and to work with railroads to minimize their impact to the communities through which they travel.

Conclusions

FRA faces a challenging task in assessing the safety impacts of longer trains and has taken some important steps to collect needed information through its study of longer trains' operations. However, without documented strategies for how it plans to communicate the results of its research, FRA may lose an opportunity to effectively work with internal and external stakeholders—such as railroads, railroad workers, and local communities—to address any risks of operating longer trains in support of the agency's mission of enabling the safe, efficient, and reliable transportation of people and goods. In addition, local community officials we spoke with raised concerns that longer trains are creating safety risks by causing emergency response delays and exacerbating dangerous motorist and pedestrian behavior, but acknowledged that they lack access to information on longer trains. FRA, however, is uniquely positioned to assess whether these concerns have merit. As FRA has stated, it expects that future growth in rail and highway traffic will increase incidences of blocked crossings and the risk of grade-crossing incidents. As traffic continues to grow—including railroads' potential increased use of longer trains—having better information could be useful to FRA and other stakeholders. Without examining the potential impacts of longer trains on local communities, including on blocked grade crossings, FRA may lose an opportunity to identify what, if any, additional actions should be taken to ensure the safety of longer trains and the communities through which they travel.

Recommendations

We are making the following two recommendations to FRA:

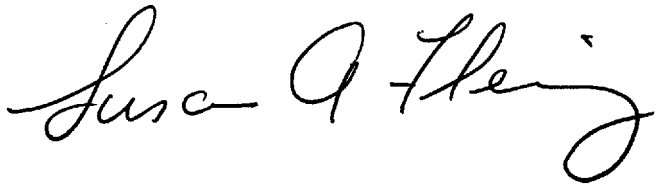
- The Administrator of FRA should develop a strategy for sharing FRA's research results with internal and external stakeholders and implement that strategy for its research on the safety impacts of very long trains. (Recommendation 1)
- The Administrator of FRA should work with railroads to engage state and local governments to (a) identify community-specific impacts of train operations, including longer trains, where streets and highways cross railroad rights-of-way and (b) develop potential solutions to reduce those impacts. (Recommendation 2)

Agency Comments

We provided a draft of this report to DOT, NTSB, and STB for their review and comment. In its comments, reproduced in appendix I, DOT concurred with the recommendations. DOT and STB also provided technical comments, which we incorporated as appropriate. NTSB had no comments.

As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of Transportation, the Chairman of NTSB, the Chairman of STB, and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or FlemingS@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.



Susan A. Fleming
Director, Physical Infrastructure Issues

Appendix I: Comments from the U.S. Department of Transportation

U.S. Department of Transportation
Office of the Secretary of Transportation

1200 New Jersey Avenue, SE
Washington, DC 20590

MAY 13 2019

Susan A. Fleming
Director, Physical Infrastructure Issues
U.S. Government Accountability Office (GAO)
441 G Street NW
Washington, DC 20548

Dear Ms. Fleming:

The Federal Railroad Administration (FRA) works to promote safety in every area of railroad operations and to reduce the occurrence of railroad-related accidents and incidents. As GAO noted in its draft report, FRA is studying rail centric operational risks associated with freight trains of over 150 cars long. Thus, FRA's study is focused on evaluating the train dynamics of operating longer trains to include, for example, train makeup, handling, and braking performance, and associated risk of derailment. Reorienting the study to assess the impact of longer freight trains on local communities would too greatly depart from the study's present objectives and contract.

FRA is also concerned about safety at grade crossings. FRA is already working with railroads and local and state governments to address blocked crossings and other community-specific impacts of train operations. For example, to address the root causes of grade crossing collisions and trespassing incidents, FRA conducts a comprehensive grade crossing safety and trespasser prevention program. Major components of the program include:

- Researching ways to improve crossing safety technology, such as in-vehicle communications and advanced crossing gate systems.
- Researching driver and pedestrian behavior at grade crossings.
- Establishing FRA grade crossing safety inspector positions to enforce Federal requirements.
- Providing grants to organizations that help motorists learn how to be safe at grade crossings.
- With the National Highway Traffic Safety Administration, implementing the public safety awareness campaign – *Stop. Trains Can't.*
- Alerting railroads to the number of blocked crossing reports FRA receives, the intensity of community concerns, best practices to reduce community-specific impacts of train operations, and the benefits of working proactively with State and local governments along the railroads' rights-of-way.

While FRA is concerned about blocked crossings as well as every rail-related accident and incident, a Federal one-size-fits-all approach is not the best way to respond to every issue. Specifically, for blocked crossings, State and local governments are better positioned to address each community's unique road network and emergency service characteristics and needs, in consultation with the railroads. FRA, however, will continue to work with State and local governments, and the railroad industry, to develop potential solutions to reduce community-specific impacts of trains operations.

Upon review of GAO's draft report, we concur with both recommendations to FRA. We will provide a detailed response to each recommendation within 180-days of the final report's issuance.

We appreciate the opportunity to respond to the draft report. Please contact Madeline M. Chulumovich, Director, Audit Relations and Program Improvement, at (202) 366-6512, with any questions or if you would like to obtain additional details.

Sincerely,

Keith Washington
Deputy Assistant Secretary for Administration

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Susan A. Fleming, (202) 512-2834 or FlemingS@gao.gov

Staff Acknowledgments

In addition to the contact named above, Andrew Huddleston (Assistant Director); Jean Cook (Analyst in Charge); Jason Coates; Philip Farah; David Hooper; Rosa Leung; Gail Marnik; John Mingus; Madhav Panwar; Malika Rice; Kelly Rubin; and Michelle Weathers made key contributions to this report.

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EXHIBIT 31

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Statistical Analysis of Train Derailment Severity for Unit Trains Versus Manifest Trains

Weitian Li[1], Zheyong Bian[2], and Xiang Liu[1]

Abstract

Using freight trains is a cost-effective and safe method for transporting numerous products over long distances. However, freight train derailments have significant consequences. Derailment severity, measured by the number of cars derailed per derailment, is an important risk factor. Based on prior literature and Federal Railroad Administration data, this research analyzes and estimates derailment severity of freight railroad transportation using a statistical method: the Truncated Geometric (TG) model. The methodology accounts for three train types: manifest train, loaded unit train, and empty unit train. Train length, speed, and gross tonnage per car are the input features, and the output variable is the number of cars derailed in a derailment incident. The TG model quantifies the influence of these factors contributing to derailment severity and estimates train derailment severity with a performance of the mean square error (MSE) of 68.91 and mean absolute error (MAE) of 6.05. When data outliers such as abnormally high or low severity are excluded, the MSE drops to 36.82 and the MAE drops to 4.22. Overall, the results indicate that the train derailment severity estimation performance based on the given factors is satisfactory. With all other factors being equal, a loaded unit train is likely to derail more cars than a manifest train and an empty unit train. When data outliers are excluded, there is no significant difference between manifest trains and empty unit trains as regards derailment severity, and both are less likely to derail than a loaded unit train.

Keywords

rail, freight rail transportation, freight, rail safety

Railroads are some of society's most critical infrastructures for transporting goods across great distances. It is essential to manage and minimize railroad safety risks to avoid potentially massive loss of life and public property. Freight railroads account for about 40% of the United States' long-distance freight volume, which is more than any other mode of transportation (*1*). In recent years, there have been several incidents of train derailments on freight railways, some of which were associated with hazardous material leaks. In October 2022, twenty tanker cars of paraffin wax from a 101-car train derailed in Sandusky, Ohio (*2*). In January 2023, sixteen total cars derailed from a train and two of them leaked chemicals in Keachi, Louisiana (*3*). In February 2023, a total of thirty-eight trains derailed in East Palestine, near the Ohio–Pennsylvania border, and eleven out of twenty tank cars carrying hazardous material subsequently ignited (*4*).

Unit trains and manifest trains are the two main types of freight trains in the U.S. Unit trains are designed to carry a single commodity, such as coal or grain, and are shipped from one shared origin to one destination. Unit trains are cost-effective and efficient because of reduced operating expenses, bulk loading, improved asset utilization, and cost savings through increased scale (*5–9*). Unit trains have been used to transport an increasing proportion of hazmat over the past two decades, and unit trains accounted for approximately 21% of hazmat carloads in 2018 (*9*). Manifest trains, as opposed to unit trains, are

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used for transporting a variety of goods and commodities and typically consist of different types of rail cars for multiple shippers (*10*).

According to train derailment data from the Federal Railroad Administration (FRA) rail equipment accident database, there were 2,669 unit train derailments and 5,931 manifest train derailments on mainlines from 1996 to 2021 (*11*). Zhang et al. conducted an empirical analysis of freight train derailment rates for unit trains and manifest trains using FRA mainline freight train derailment data for the years 1996 to 2018 and found that the weight and length of trains involved in derailments of unit trains are statistically larger than those of manifest trains (*9*). Additionally, the average number of cars derailed in unit trains and manifest trains was significantly different, with 11.3 and 7.6 cars derailed on average, respectively (*9*). Thus, the derailment risk and severity for manifest trains and unit trains are different.

Train derailment severity analysis is an essential part of hazmat transportation risk analysis. This report belongs to a broader study of the effects of train configuration on railroad hazmat transportation risk. Therefore, estimating the train derailment severity for two major trains and quantifying the relationship between train derailment severity and associated affecting factors are pivotal for comprehending risks associated with freight transportation, including hazardous material by rail, as well as for aiding the rail industry and government to develop, evaluate, prioritize, and implement cost-effective safety-enhancement strategies.

For a train derailment incident, the number of derailed cars is greater than or equal to one and less than or equal to the residual train length, including locomotives and railcars. In this paper, the number of derailed cars following a train derailment is used to measure the derailment severity. Previous studies focused on the probability of a train derailment and developed various methods to measure derailment severity (*12–15*). The truncated geometric (TG) model is one of the most mainstream and effective of these methods. The TG model can truncate the number of derailed cars starting from one and extending to the residual train length. Although previous research has focused on attributes such as residual train length, derailment speed, and loading factor, relatively few studies have investigated the derailment rates of unit trains and manifest trains on the mainlines of freight networks. There remains a lack of more fine-grained quantity analysis of derailment severity for different types of trains. In this research, we conduct a detailed exploratory data analysis of the most recent train accident data from the FRA and investigate and clarify the corresponding impact of train types and factors, including train length, gross tonnage, and train speed. Based on selected train derailment data from the FRA, the TG model is utilized to estimate derailment severity for different types of freight trains. There might be a significant difference between loaded unit trains, empty unit trains, and manifest trains in train length, gross tonnage, and train speed, which might inversely affect derailment severity. Ultimately, the relationship between train derailment severity and train types and related affecting factors can be quantified for the government and railroad industry to develop more cost-effective accident-prevention strategies.

Literature Review

Statistical models have been developed using historical accident data to estimate expected severity based on associated factors such as train speed, position of the derailment, and the proportion of loaded and empty cars within a train (*12–15*). These models are effective at estimating train derailment severity as well as identifying risk factors that influence train derailment severity.

For instance, Liu et al. developed zero-truncated negative binomial regression and quantile regression models to estimate the conditional mean of freight train derailment severity based on residual train length, derailment speed, and loading factor, using data from historical derailments on U.S. Class I railroad mainlines from 2001 to 2010 (*12*). Additionally, Saccomanno and El-Hage developed a TG model to estimate the mean number of cars derailed as a function of derailment speed, residual train length, and accident cause (*16*, *17*). Martey and Attoh-Okine developed a joint mixed copula-based model to estimate derailed cars and monetary damage, and conducted a combined analysis of their relationship with a set of covariates that might affect both outcomes (*13*). Martey and Attoh-Okine employed a vine copula quantile regression model, an interval estimation approach, to predict conditional mean and quantiles of derailment severity outcomes, considering derailment speed, residual length, loading factor, derailed cars, and monetary damage (*14*). Bagheri used a TG model to estimate the number of cars derailed per train derailment (*18*). Liu built a negative binomial regression model to estimate the number of cars derailed in the United States between 2000 and 2014 based on year, track type, annual traffic volume, and accident cause (*19*). Li et al. conducted a quantitative analysis of the derailment characteristics of loaded and empty unit trains to determine the frequency of derailments for both (*7*). Kang et al. developed a probabilistic risk analysis model for railroad hazmat transportation risk modeling and presented a practical case study comparing unit and manifest trains transporting hazardous materials (*20*).

These studies show that statistical methods can be applied and train types can be considered in train

derailment estimation. In the past decade, some researchers have used machine learning to investigate the relationship between train derailment and associated factors (*21*, *22*). Lotfi et al. predicted the severity of train derailment utilizing decision tree, random forest, support vector machine, and other machine learning techniques (*21*). Song et al. conducted a quantitative analysis of freight train derailment severity with structured and unstructured data by combining latent dirichlet allocation (LDA) and a zero-truncated negative binomial model (*22*). Machine learning-based methods are increasingly a research focus and continue to yield valuable insights.

Knowledge Gaps and Our Goals

Previous machine learning-based studies do not show a great ability to quantify and explain the impact of each factor on train derailment. Current methods based on the TG model focus on limited attributes and only estimate the mean of freight train derailment severity. Limited previous research has estimated derailment severity pertaining to the use of different types of trains (*9*, *23*, *24*). Even fewer studies have focused on the difference between loaded and empty unit trains versus other types of trains for the same traffic demand. This research addresses these gaps by presenting a comprehensive freight train derailment factor analysis and derailment severity estimation based on the TG model, train types, and other associated factors.

This paper aims to: (1) define and identify factors that influence derailment severity, given a train derailment incident; (2) build a TG model to estimate derailment severity, given a set of influencing factors; and (3) estimate train derailment severity based on the dataset from the FRA using the TG model. The remainder of this paper is organized as follows: the next section describes the data sourced from the FRA and corresponding exploratory data analysis. Following that section is an explanation of the methodology implemented in this work, namely the TG model, to identify factors that influence derailment severity and to estimate derailment severity. Subsequently, the results are interpreted and implications are discussed. The last section concludes the estimation of train derailment severity and analysis of influencing factors, clarifies the contribution of this paper, and discusses future work.

Data Source and Exploratory Data Analysis

Data Source

The Rail Equipment Accident/Incident Form 6180.54 (REA), published by the FRA of the U.S. Department of Transportation (USDOT), records the time, cause, severity, consequence, and contributing factors of each train accident (*11*). This research uses freight train derailment data on the main tracks of Class I railroads, the largest railroads by revenue operating in the United States, from 1996 to 2021 for train derailment severity analysis, which covers all available data consistent with our derailment rate analysis.

Many previous studies have used the "number of derailed cars" to measure derailment severity (*7*, *12*, *16*, *17*). The generic term "cars" refers to all types of vehicles, such as locomotives, railcars, and cabooses, unless specifically stated otherwise. Monetary damage and the number of casualties are also used to assess derailment severity. However, prior studies have stated that monetary damage is prone to substantial variation because of factors such as the cost difference between locomotives and railcars and differences in repair costs between regular track and special track (like turnouts and crossings), and that casualties are more appropriately included in the measurement of passenger train derailments (*13*, *25*). As this research focuses on freight train derailments, this section primarily uses the number of cars derailed as a derailment severity metric in its study of unit train and manifest train derailment severity analysis.

Figure 1 shows the average train derailment severity for each year to demonstrate whether there is a statistical trend over the years from 1996 to 2021. This figure does not show an obvious increasing or decreasing trend in average derailment severity from 1996 to 2021. We use the Mann–Kendall Trend Test to verify the significance of increasing or decreasing trends in derailment severity. The Mann–Kendall Trend Test (*26*) is a non-parametric test for analyzing time series data with consistent increasing or decreasing trends. We find that train derailment severity does not have a significant increasing or decreasing trend over time. This is because the p-value (0.895) is greater than the 0.05 confidence level, and we can thus reject the null hypothesis that the data have a significant increasing or decreasing trend. Therefore, we can conclude that, statistically, derailment severity for the 25 years from 1996 to 2021 does not change significantly over time, and we can conduct an integrated analysis of derailment severity for all years from 1996 to 2021 instead of a separate derailment severity analysis for each individual year.

Using the freight train derailment data collected from 1996 to 2021, the distribution of the number of cars derailed is plotted in Figure 2, excluding data with derailment speed equal to "0 mph" or the number of derailed cars equal to "0". Figure 3 presents the same data separated by train type for the unit trains and manifest trains' distributions of the number of derailed cars, and the comparison between them. Table 1 presents descriptive statistics for train derailment severity analysis. Most derailment accidents are manifest train derailments

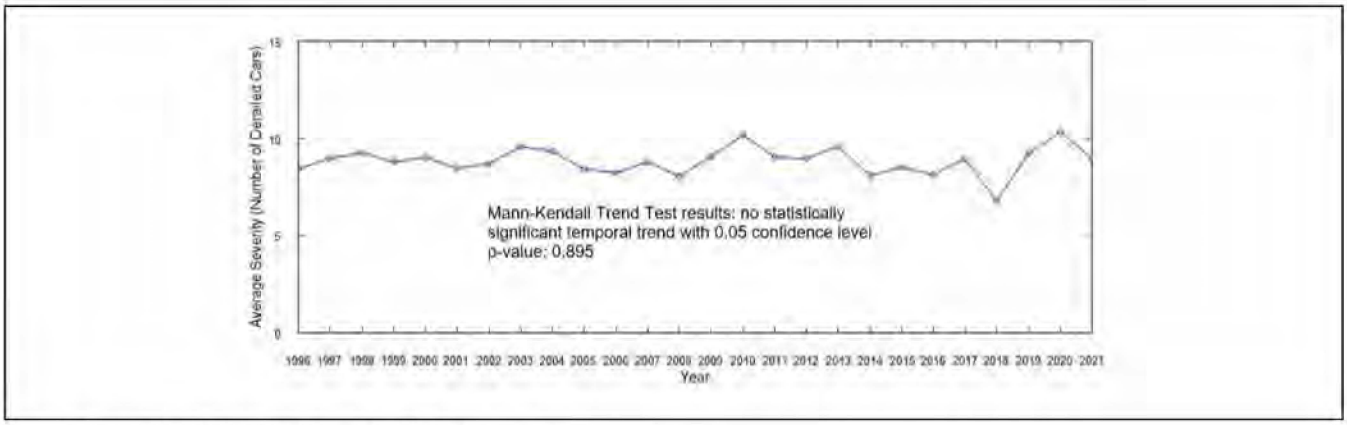


Figure 1. Average train derailment severity each year.

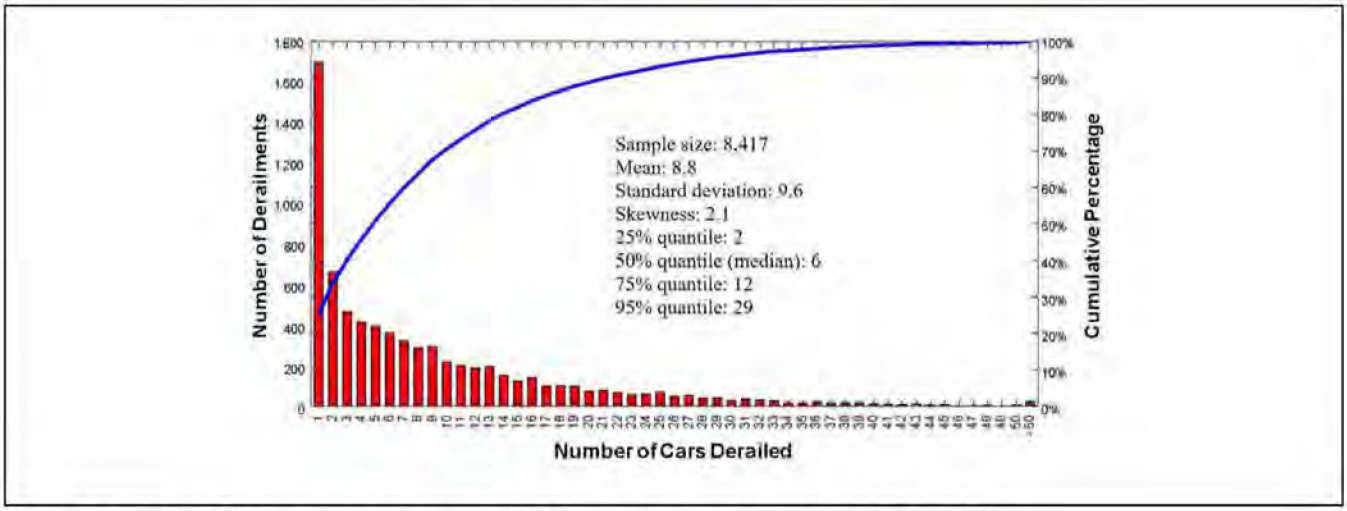


Figure 2. Number of railcars derailed per freight train derailment (all train types) from 1996 to 2021.

(69%), and the corresponding average number of derailed cars is 7.7, whereas the average numbers of derailed cars for all train types and for unit trains specifically are 8.8 and 11.3, respectively. These facts indicate that manifest trains may primarily affect the estimation of train derailment severity.

Exploratory Data Analysis

Before developing statistical models to estimate train derailment severity, we conduct data screening to exclude data with inappropriate attributes which may degrade the model's performance. The following screening conditions are applied; 8,160 train derailments (94.88% of all 8,600 derailments) are selected for analysis.

- Speed $\geqslant$ 1: In the dataset, 145 derailment incidents' speeds are 0 miles per hour. We assume that a train will not derail when train speed is extremely slow. Thus, we set the lowest derailment speed as "1 mile per hour" and these 145 derailment incidents (1.68% of all 8,600 derailments) are excluded from subsequent analysis.
- Number of derailed cars $\geqslant$ 1: In the original dataset, some numbers of derailed cars and locomotives were zero. However, when the number of derailed cars is zero, we deem that the train did not derail, and thus the incidents with zero derailed cars are excluded from our analysis. This screening criterion removes sixty-seven derailment incidents (0.78% of all 8,600 derailments) from the dataset.
- Number of cars behind the point of derailment (POD) $\geqslant$ Number of derailed cars: In this paper, POD refers to the position of the first derailed vehicle (FDV). It is impossible for the number of cars behind the POD to be less than the number of derailed cars, and thus we only consider data

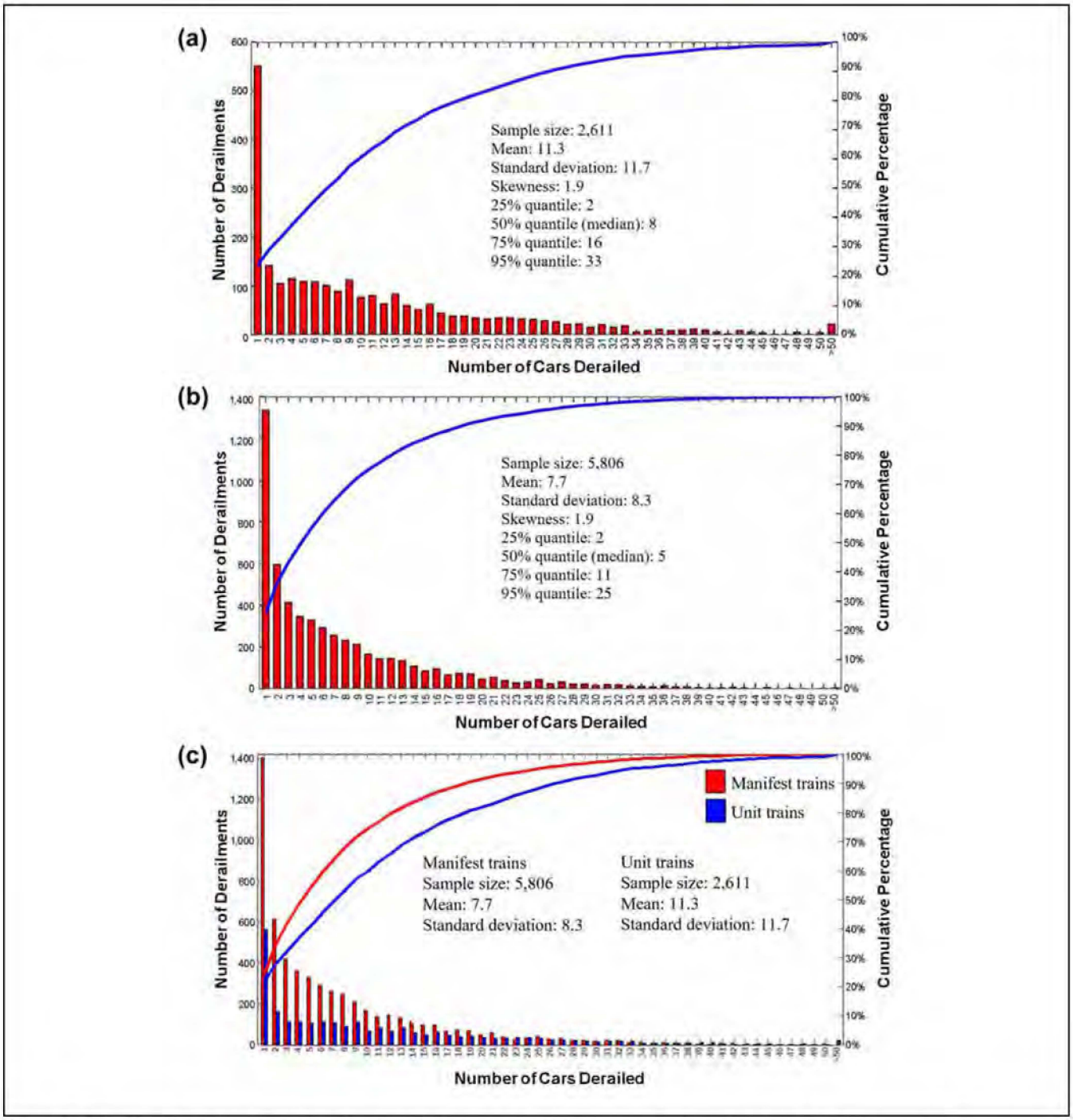


Figure 3. Number of railcars derailed per freight train derailment in: (*a*) unit trains, (*b*) manifest trains, and (*c*) comparison.

Table 1. Descriptive Statistical Results

	Sample size (number of train derailments)	Mean (average number of derailed cars)	Median (the median number of derailed cars)	Variance (the variance of numbers of derailed cars)	Standard deviation of numbers of derailed cars
All train types	8,417	8.8	6	92.3	9.6
Unit trains	2,611	11.3	8	135.9	11.7
Manifest trains	5,806	7.7	5	68.8	8.3

with the number of cars behind the POD greater than or equal to the number of derailed cars. In addition, we assume there is only one POD per accident. The POD information is from the FRA safety database and its accuracy could potentially affect the results. In the dataset, there are 179 derailment incidents (2.08% of all 8,600 derailments) whose numbers of cars behind the POD are less than the numbers of derailed cars, and these data are excluded from our analysis.

- Other data with apparent errors (seventy-nine data records [0.92% of all 8,600 derailments], e.g., tons per car equal to 0, two data records for one derailment incident) are excluded.

Out of the 8,160 train derailments, 2,120 data points refer to loaded unit trains, 414 data points refer to empty unit trains, and 5,626 data points refer to manifest trains.

The response variable is the total number of railcars derailed, including loaded railcars, empty railcars, and locomotives. Several engineering and operational factors may affect train derailment severity. Based on the literature, estimator variables are identified for statistical analysis, and include train derailment speed, residual train length, gross tonnage per car, and train type.

Train Speed. Train derailment speed is the speed of train operation when the accident occurs. This factor's effect on derailment severity is most widely studied in the literature (*12, 17, 27, 28*). It has been found that, given all other factors are equal, derailment speed is positively associated with the number of cars derailed. This finding is reasonable because speed is an indicator of an accident's kinetic energy.

Residual Train Length. Residual train length is defined as the number of railcars behind the POD, which is the maximum number of cars potentially subject to derailment. Figure 4 illustrates the POD and residual train length. Saccomanno and El-Hage (*17*), Anderson (*27*), and Liu et al. (*12*) found that a greater residual train length is associated with more derailed cars if a derailment occurs.

Gross Tonnage per Car. Liu et al. verified the hypothesis that a train carrying a larger proportion of loaded cars is expected to derail more cars (*12*). Therefore, we consider the gross tonnage per car as a factor that influences derailment severity. Higher gross tonnage per car in the train may also indicate greater kinetic energy in the derailment, thereby causing more cars to derail, given all else being equal.



Figure 4. An illustrative example of point of derailment and residual train length.

Train Type. Train type is the new factor considered in this research. There is no data field in the FRA REA database to directly identify train type (i.e., unit or manifest train). In this research, we classify train types based on previous studies (*7, 9*). We identify unit trains and manifest trains using the railroad code, train symbol ID, causing car reporting mark and number, number of empty cars, number of loaded cars, number of locomotives, and narratives recorded in the REA database. According to several variables extracted from the accident database, including the number of empty cars, the number of loaded cars, the number of locomotives, the length of the train considering the total number of cars and locomotives, and the percentage of loaded or empty railcars in the train, a train is classified as loaded if 95% or more of its cars are loaded, or as empty if 95% or more of its cars are empty (Figure 5) (*9*). These percentages were calculated by dividing the number of loaded or empty cars by the total number of cars in the train. The percentage of "95%" of loaded or empty cars is used as the threshold to measure whether a train is a unit train or a manifest train (instead of the percentage of "100%") because of the buffer cars required by federal regulation (*29*) whose loading condition is independent of the loading condition of the rest of the train. This same threshold was used in the previous study (*7*) to determine the loading conditions of freight trains. Buffer cars can either be empty or loaded with an inert material. In this research, a train that is not more than 95% loaded or not more than 95% empty is directly defined as manifest train. To determine whether a train is a unit train or a manifest train, further steps are required to identify train type when it is more than 95% loaded or empty, while the remaining trains with partially loaded consists are generally manifest trains. For example, train numbers with prefixes of "C," "G," or "U" stand for loaded unit coal trains, loaded unit grain trains, and loaded unit trains carrying materials other than coal or grain, respectively,

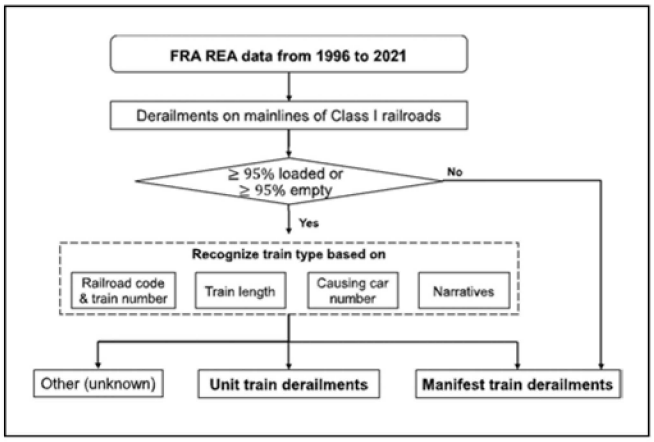


Figure 5. Methodology for classifying type of derailed trains (*9*).

whereas "M" represents manifest trains, following BNSF Railway's symbol guide (*30*).

We consider three types of trains: loaded unit trains, empty unit trains, and manifest trains. There may be significant differences in train length, gross tonnage, and train speed for loaded unit trains, empty unit trains, and manifest trains, which may influence derailment severity, as shown in Table 2. The average total numbers of cars per train for both the loaded unit train and empty unit train are greater than the manifest train, with a small difference between the loaded unit train and empty unit train. The average tonnage per car of a loaded unit train is remarkably larger than empty unit trains and manifest trains, which may increase the corresponding train derailment severity. We use the one-way analysis of variance (ANOVA) to analyze the differences between the means of two or more groups. The one-way ANOVA (*31*) compares the variance within groups with the variance between groups and, based on the results, it determines whether there is a statistically significant difference between the means of the groups being compared. As shown in Table 3, one-way ANOVAs are performed to evaluate the existence of statistical differences in these attributes among train types. We find that these attributes among train types considered in the one-way ANOVA are significant, with all p-values being less than 0.05. The results indicate that there was a statistically significant difference in these attributes between all three train types. These attributes of all three train types with different distributions indicate that these factors have significant influences on derailment severity. Moreover, train type represents some unobserved, hidden factors besides tonnage, train length, speed, and so forth. Therefore, train type is also treated as a variable. Table 4 summarizes the input variables considered for the severity estimation model.

Methodology

Truncated Geometric Model

Given that a train derailment incident occurs, the number of cars derailed must be greater than or equal to "1" and less than or equal to the residual train length. As verified by Bagheri (*18*), the number of cars derailed follows a TG distribution and the TG model can truncate the number of derailed cars beyond the range from "1" to the residual train length. For a train derailment event with train length L and POD j (the residual train length

Table 2. Attributes of Loaded Unit Trains, Empty Unit Trains, and Manifest Trains

Train types	Average residual train length (number of cars behind point of derailment)	Average tonnage per car	Average total number of cars per train	Average derailment speed (mph)
Loaded unit trains	58	131	109	25.3
Empty unit trains	72	32	111	26.7
Manifest trains	50	85	86	24.5

Table 3. One-way ANOVA Result of Train Types and Attributes

Factor	DF	*F*-value	*p*-value
Average residual train length (number of cars behind point of derailment)	2	89.97	$< 2\times10^{-16}$
Average tonnage per car	2	2060	$< 2\times10^{-16}$
Average total number of cars per train	2	392	$< 2\times10^{-16}$
Average derailment speed (mph)	2	4.961	0.00703

Note: ANOVA = analysis of variance; DF = degrees of freedom.

Table 4. Variables in Derailment Severity Estimation Models

Variables	Data type
Model input	
Gross tonnage per car	Continuous variable
Train derailment speed (miles per hour)	Continuous variable
Number of cars behind point of derailment	Integer
Train types including loaded unit trains, empty unit trains, and manifest trains	Category
Model output	
Number of cars derailed in one derailment	Integer

$Lr = L - j + 1$), the probability of derailing x cars can be calculated by:

$$P(X = x|POD \text{ at } j) = \begin{cases} \dfrac{p(1-p)^{x-1}}{1-(1-p)^{Lr}} & \text{if } x = 1, 2, ..., Lr \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where

Lr: residual train length

x: number of cars derailed

p: the probability of success at each trial, which is a constant probability. In other words, if a derailment has occurred, "x" cars derailing before the first non-derailing car is a geometric distribution and the probability of a car derailing is equal to $(1-p)$. This probability p is assumed to be related to the factors/covariates through the logit link function:

$$p = \frac{e^Z}{1+e^Z} \quad (2)$$

where Z is a linear function (Equation 3) of influencing factors, including derailment speed, residual train length, gross tonnage per car, and train type.

$$\begin{aligned} Z = {} & \beta_0 + \beta_1(speed) + \beta_2(cars\ residual) \\ & + \beta_3(tons\ per\ car) + \beta_4(empty\ unit\ train) \\ & + \beta_5(loaded\ unit\ train) \end{aligned} \quad (3)$$

speed: Train derailment speed (miles per hour)

cars residual: Number of cars behind POD

tons per car: Average gross tonnage per car

empty unit train: If the train is an empty unit train, *empty unit train* = 1, otherwise *empty unit train* = 0

loaded unit train: If the train is a loaded unit train, *loaded unit train* = 1, otherwise *loaded unit train* = 0

The model uses the manifest train as a reference, which means that the manifest train type variable is not included in the model. A detailed introduction of the TG model can be found in Bagheri (*18*).

We use the VGAM package in R to fit the TG model. The VGAM package (*32*) in R aims to fit Vector Generalized Linear and Additive Models (VGLMs and VGAMs), as well as reduced-rank VGLMs (RR-VGLMs) and quadratic RR-VGLMs (QRR-VGLMs). It is a general program for maximum likelihood estimation. In this research, the VGAM package is able to fit the TG model using the function "truncgeometric()".

Model Results

Table 5 presents the results of the model. We find that except for the variable "empty unit train," all other variables considered in the TG model are significant, with all p-values being less than 0.05. Thereafter, we get the model result of the Z function in Equation 4.

$$\begin{aligned} Z = {} & -0.908 - 0.0313(speed) - 0.00239(cars\ residual) \\ & - 0.00240(tons\ per\ car) - 0.340(loaded\ unit\ train) \end{aligned} \quad (4)$$

In Equation 4, if the coefficient of a variable is negative, then increasing this variable would tend to increase derailment severity. In contrast, if the coefficient of a variable is positive, then increasing the variable would tend to decrease derailment severity. The reason can be interpreted as follows. Based on Equation 2, the probability of a car not to derail (p) is a monotone increasing function of "Z," and thus the probability of a car to derail $(1-p)$ is a monotone decreasing function of "Z." When a variable is increased, given that its coefficient in

Table 5. Truncated Geometric Model Results for All Train Types with Outliers

Variables	Definition	Coefficient	p-value
Intercept	The constant	−0.908	$< 2\times10^{-16}$
speed	Train derailment speed (miles per hour)	−0.0313	$< 2\times10^{-16}$
cars residual	Number of cars behind point of derailment	−0.00239	3.65×10^{-8}
tons per car	Average gross tonnage per car	−0.00240	1.23×10^{-6}
empty unit train	If the train is an empty unit train, *empty unit train* = 1, otherwise *empty unit train* = 0	0.0783	0.243
loaded unit train	If the train is a loaded unit train, *loaded unit train* = 1, otherwise *loaded unit train* = 0	−0.340	5.19×10^{-16}

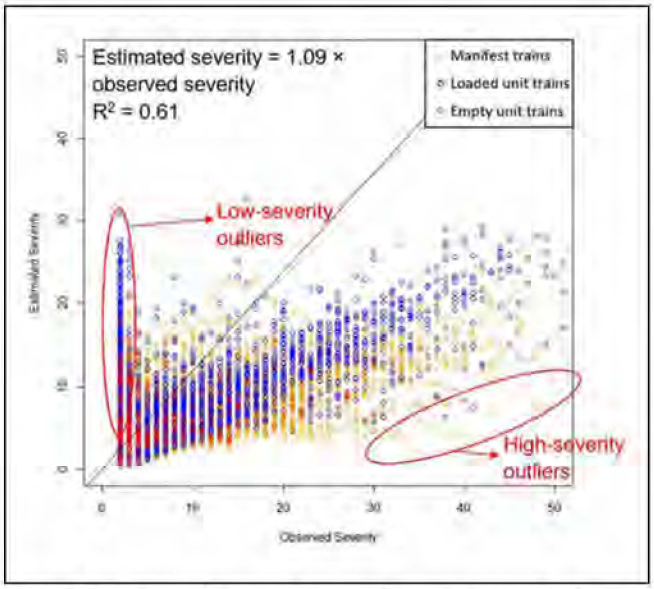


Figure 6. Estimated severity versus observed severity with outliers.

Z function is negative, Z decreases and then the probability of a car to derail increases, and thus derailment severity tends to increase, and vice versa. Based on this discussion, we offer the following interpretation of the obtained model.

- The coefficient of derailment speed is −0.0313. This indicates that higher derailment speed is associated with increased derailment severity.
- The coefficient of residual train length is −0.00239. The negative value indicates that longer residual train length is associated with increased derailment severity.
- Similarly, greater gross tonnage per car is associated with increased derailment severity.
- The coefficient of "loaded unit train type" is −0.340. This means that a loaded unit train tends to have more cars derailed compared with a manifest train or an empty unit train, given all else being equal.

We use the mean number of cars derailed as the estimated derailment severity, as formulated by Equation 5.

$$D = E[X] = \sum_{x=1}^{Lr} P(x)x = \frac{1}{p\left[1-(1-p)^{Lr}\right]} \quad (5)$$

Figure 6 plots the estimated severity versus the observed severity. Because of low-severity outliers (i.e., those incidents where estimated severity is high but observed severity is low) and high-severity outliers (i.e., those incidents where estimated severity is low but observed severity is high), the R square is not sufficiently large (0.61), which indicates that the model does not estimate the severity perfectly.

One of the concerns identified by this result is that there are different types of behaviors in the derailment data and the variation cannot be represented well by this type of model. Thus, we analyze train derailment data through a physical model (*33*) that can model typical derailments. For example, the derailment data include a significant number (approximately 20%) of single-car derailments (severity = 1) with a wide range of derailment speeds. These often result from mechanisms like a broken wheel or axle, and are situations where a single truck might derail but the problem is identified and the train is brought to rest by the operator, initiating no larger derailment severity. All cars in the train remain connected and upright, primarily aligned with the track. Liu et al. analyzed the causes of major train derailment and revealed that equipment is the main cause of train derailment at derailment speeds greater than 25 mph (*34*).

In other extreme derailments, the train is moving very slowly and an initiating event, such as extreme weather, causes a long string of connected cars to fall over, remaining aligned with the track. According to our findings based on accident narratives in the FRA REA database, we can assume that if there are empty tank cars with double shelf couplers and one of these cars rolls off its tracks in a derailment, the strong rotational coupling between the cars could result in a long line of trailing cars rolling over. These events can have very high severities even at low speeds or no speed.

Consequently, we conducted additional analysis of the data where we excluded the high-severity and low-severity outliers. Nayak et al. proposed a positive nonlinear relationship between derailment speed and the mean of derailed cars, and expressed the mean number of derailed cars as a function of the square root of the derailment speed (*15*). Martey and Attoh-Okine employed a vine copula quantile regression model to analyze the relationship between derailment speed and derailment, which showed the marginal effects of derailment speed in their model with different alpha values (*14*). Therefore, we developed a method to exclude these outliers and then used the TG model again to estimate derailment severity. Considering that we covered most of the derailment data and improved the TG model's performance, we determined the threshold for excluding outliers by inferring from previous research (*14*, *15*, *33*, *34*) and several trials. Derailment data outside the range from 0.1 × derailment speed to 1.6 × speed are treated as outliers and are excluded from analysis (Figure 7). The derailments outside these bounds are assumed to have a "unique behavior" compared with typical derailments. Using this outlier elimination method, 5,849

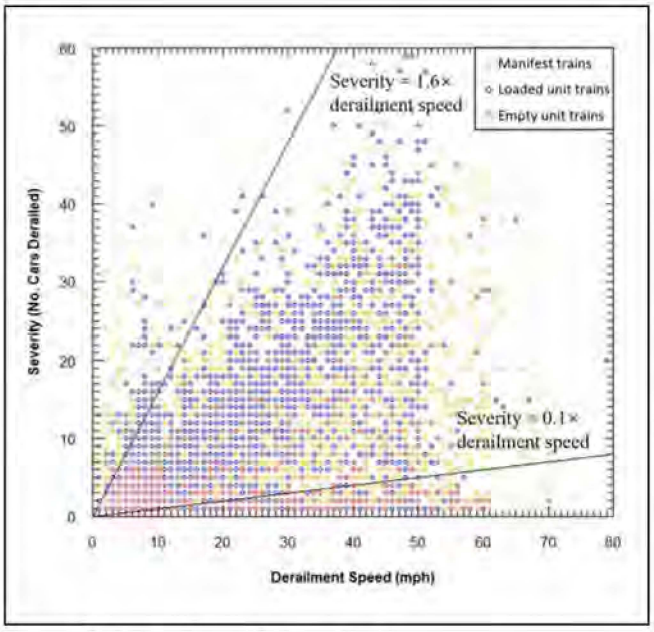


Figure 7. Method to exclude outliers.

derailment data are selected from the total 8,160 train derailments; 2,311 outliers are excluded, among which 2,004 derailment data are low-severity outliers and 307 derailment data are high-severity outliers. Among the 5,849 train derailments, there are 1,581 data records from loaded unit trains, 299 data records from empty unit trains, and 3,969 data records from manifest trains. The result of the TG model is presented in Table 6 and Equation 6.

$$Z = -0.587 - 0.0709(speed) - 0.00171(cars\ residual) - 0.00252(tons\ per\ car) - 0.332(loaded\ unit\ train) \quad (6)$$

Mean squared error (MSE, Equation 7) and mean absolute error (MAE, Equation 8) are selected to measure the performance of TG models in estimating train derailment severity. For all data with outliers, the MSE and MAE of the model are 68.91 and 6.05, respectively. For the data without outliers, the MSE and MAE of the model are 36.82 and 4.22, respectively. The MAE indicates that the average gap between the estimated number of derailed cars and the observed number of derailed cars is "6.05" and "4.22" for the data with and without outliers, respectively. Figure 8 plots the estimated severity versus the observed severity without outliers.

$$\text{MSE} = \text{mean}\left[(\text{estimated severity} - \text{observed severity})^2\right] \quad (7)$$

$$\text{MAE} = \text{mean}\left[|\text{estimated severity} - \text{observed severity}|\right] \quad (8)$$

The TG regression model is also used to separately fit the derailment severities for the loaded unit train, empty unit train, and manifest train. Equations 9 and 10 calculate the TG model results for loaded unit train derailment severity based on the data including and excluding outliers, respectively. The effect of average gross tonnage per car on the derailment severity for the data both with and without outliers is insignificant.

$$Z = -1.492 - 0.0423(speed) - 0.00119(cars\ residual) \quad (9)$$

$$Z = -1.216 - 0.0785(speed) - 0.00504(cars\ residual) \quad (10)$$

Equations 11 and 12 calculate the TG model results for empty unit train derailment severity based on the data including and excluding outliers, respectively. In the model based on the data with outliers, the effects of average gross tonnage per car on the derailment severity are insignificant. In the model based on the data without outliers, the effects of average gross tonnage per car and residual train length on the derailment severity are insignificant.

$$Z = -0.597 - 0.0330(speed) - 0.00573(cars\ residual) \quad (11)$$

Table 6. Truncated Geometry Model Results for all Train Types without Outliers

Variables	Definition	Coefficient	*p*-value
Intercept	The constant	−0.587	4.90×10^{-16}
speed	Train derailment speed (miles per hour)	−0.0709	$<2\times10^{-16}$
cars residual	Number of cars behind POD (point of derailment)	−0.00171	0.0025
tons per car	Average gross tonnage per car	−0.00252	5.02×10^{-5}
empty unit train	If the train is an empty unit train, *empty unit train* = 1, otherwise *empty unit train* = 0	0.123	0.151
loaded unit train	If the train is a loaded unit train, *loaded unit train* = 1, otherwise *loaded unit train* = 0	−0.332	7.84×10^{-10}

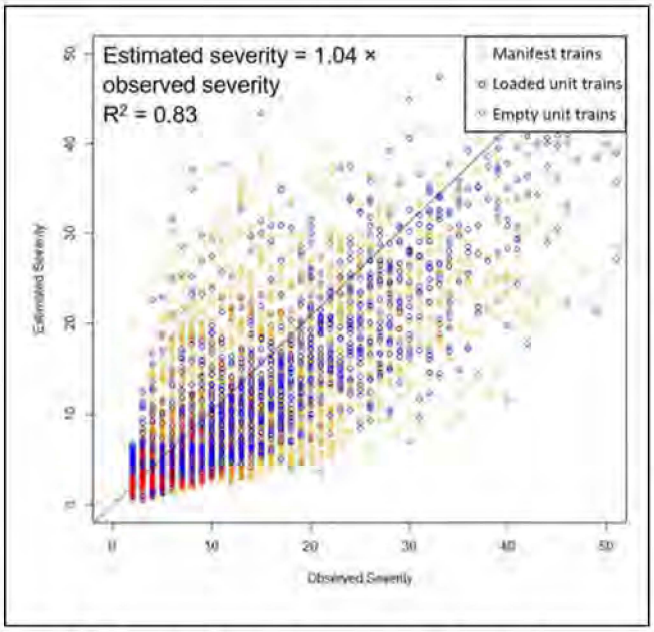


Figure 8. Estimated severity versus observed severity without outliers.

$$Z = -0.416 - 0.0614(speed) \quad (12)$$

Equations 13 and 14 calculate the model results for derailment severity of manifest trains based on the data with and without outliers, respectively. All considered variables and the intercept are significant for both models based on the data with and without outliers.

$$Z = -0.858 - 0.0289(speed) - 0.00335(cars\ residual) - 0.00291(tons\ per\ car) \quad (13)$$

$$Z = -0.498 - 0.0699(speed) - 0.00320(tons\ per\ car) \quad (14)$$

Table 7 summarizes the performance of TG models at estimating train derailment severity for loaded unit trains, empty unit trains, and manifest trains. The MSE (Equation 7) and MAE (Equation 8) are used as criteria to measure performance. We found that the TG model has a better performance when outliers are excluded. Overall, the performance of the TG model is acceptable: the models with outliers all have MAEs less than 7.5, and the models without outliers all have MAEs less than 5. Based on these results excluding data outliers, we propose the following interpretations of the obtained model.

- The coefficient of derailment speed is −0.0709. This reveals that higher derailment speed is associated with increased derailment severity.
- The coefficient of residual train length is −0.00171, which is also negative, indicating that longer residual train length is associated with increased derailment severity.
- The coefficient of gross tonnage per car is −0.00252. Correspondingly, greater gross tonnage per car is associated with increased derailment severity.
- Similar to the situation considering the data outliers, the coefficient of "loaded unit train type" is also negative, with a value of −0.332. Given all else being equal, this means that a loaded unit train tends to have more cars derailed compared with a manifest train and an empty unit train.

Table 7. Summary of Model Performance of Truncated Geometry Model

Data	Model results	Mean square error	Mean absolute error
All train types			
With outliers	$Z = -0.908 - 0.0313(speed) - 0.00239(cars\ residual) - 0.00240(tons\ per\ car) - 0.340(loaded\ unit\ train)$	68.91	6.05
Without outliers	$Z = -0.587 - 0.0709(speed) - 0.00171(cars\ residual) - 0.00252(tons\ per\ car) - 0.332(loaded\ unit\ train)$	36.82	4.22
Loaded unit trains			
With outliers	$Z = -1.492 - 0.0423(speed) - 0.00119(cars\ residual)$	96.91	7.04
Without outliers	$Z = -1.216 - 0.0785(speed) - 0.00504(cars\ residual)$	39.46	4.34
Empty unit trains			
With outliers	$Z = -0.597 - 0.0330(speed) - 0.00573(cars\ residual)$	83.76	6.13
Without outliers	$Z = -0.416 - 0.0614(speed)$	45.71	4.80
Manifest trains			
With outliers	$Z = -0.858 - 0.0289(speed) - 0.00335(cars\ residual) - 0.00291(tons\ per\ car)$	56.80	5.60
Without outliers	$Z = -0.498 - 0.0699(speed) - 0.00320(tons\ per\ car)$	34.84	4.11

Concluding Remarks

This research identifies factors that influence derailment severity, given a train derailment incident, and develops a TG model to estimate train derailment severity based on these factors. First, we conduct a comprehensive exploratory data analysis of train derailment severity and select appropriate data from the FRA for statistical analysis. Second, we systematically summarize factors that can significantly influence train derailment severity, with the train types being loaded unit train, empty unit train, and manifest train. Third, we utilize these factors to estimate train derailment severity and quantify the influence of these factors, which provides further insights into train derailment severity.

Based on the severity estimation results obtained by the TG model, factors that can significantly influence train derailment severity are identified; these include train speed, residual train length, gross tonnage per car, and train type. The results indicate that increased derailment severity is associated with higher derailment speed, longer residual train length, and greater gross tonnage per car. Given all other factors are the same, a loaded unit train tends to have more cars derailed compared with a manifest train and an empty unit train.

We conducted additional analysis excluding low and high-severity outliers, and estimated derailment severity using the TG model. The results show that the TG model achieves better estimation performance when outliers are excluded. Given all other factors being equal, a loaded unit train tends to have more cars derailed compared with a manifest train and an empty unit train, whereas there is no significant difference in derailment severity between a manifest train and an empty unit train. For the empty unit train and loaded unit train, the effect of average gross tonnage per car on the derailment severity is insignificant for the data both with and without outliers, whereas the average gross tonnage is significant for the derailment severity of the manifest train.

However, statistical models may have difficulty predicting extreme derailment events that fall outside historical experience. Physical models are able to capture the conditions of a specific train derailment scenario by mathematically describing the physical dynamics of the derailment. In the future, we will leverage physical modeling, which could help in understanding the derailment mechanism determined by train speed, tonnage, train length, and so forth, and compare it with the statistical model to estimate train derailment severity more accurately.

Acknowledgments

The Federal Railroad Administration's (FRA) Office of Research, Development and Technology sponsored the work leading to this paper. The authors would like to acknowledge Francisco Gonzalez and Dr. Phani Raj from the FRA for their advice and guidance during this research. The authors would also like to thank Zezhou Wang, Xin Wang, Junyan Dai, and Noelle Darling from Rutgers University, and Xi Zhang from the University of Houston for their assistance on this research.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Zheyong Bian and Xiang Liu; data collection: Zheyong Bian and Weitian Li; analysis and interpretation of results: Zheyong Bian and Weitian Li; draft manuscript preparation: Weitian Li. All authors reviewed the results and approved the final version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by a research grant (693JJ619C000017) from the Federal Railroad Administration of the U.S. Department of Transportation. However, all views, analyses, and errors are solely those of the authors.

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EXHIBIT 32

Nos. 22-1019 & No. 22-1020 (consolidated)

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

EAGLE COUNTY, COLORADO,
Petitioner,

CENTER FOR BIOLOGICAL DIVERSITY, ET AL.,
Petitioners,

v.

SURFACE TRANSPORATION BOARD, ET AL.,
Respondents,

SEVEN COUNTY INFRASTRUCTURE COALITION
AND UINTA BASIN RAILWAY, LLC,
Intervenors.

RESPONSE OF FEDERAL RESPONDENTS TO CROSS-MOTIONS TO REAFFIRM VACATUR

Respondents the Surface Transportation Board (the Board) and the United States of America (jointly, Federal Respondents) respectfully submit this response to the Center for Biological Diversity's Opposition to Motion for Remand Without Vacatur and Cross-Motion to Reaffirm Vacatur (CBD Cross-Motion) and Eagle County's Opposition to Intervenor-Respondents' Motion for Remand Without Vacatur and Cross-Motion to Reaffirm Vacatur of the Surface Transportation Board's Decision (Eagle County Cross-Motion) (collectively, Petitioners' Cross-

Motions). As explained in Federal Respondents' Response to Intervenor-Respondents' Motion for Remand Without Vacatur, following the Supreme Court's decision in *Seven County Infrastructure Coalition v. Eagle, County, Colo.*, 605 U.S. __, 145 S. Ct. 1497 (May 29, 2025) (*Seven County*), remand without vacatur is appropriate. Petitioners' argument that vacatur is appropriate because *Seven County* was narrowly limited to a discrete issue is wrong.

As the Supreme Court stated, *Seven County* was a "course correction" put into motion to stop "overly intrusive (and unpredictable) review in NEPA cases." *Seven Cnty.*, 145 S. Ct. at 1513, 1514. The Supreme Court not only emphatically confirmed that the guiding principle in NEPA cases is "deference," it made clear that this deference applies to all aspects of the agency's NEPA review: from the agency's assessment of "how far to go" in assessing a project's potential effects and determination of "what facts are relevant," to its "speculative assessments or predictive or scientific judgments" and findings about "what qualifies as significant or feasible or the like." *Id.* at 1512-13. *Seven County* was an expansive decision with broad implications.

Both Petitioners' Cross-Motions rest on the faulty premise that the Supreme Court's only relevant finding in *Seven County* is that under NEPA the Board was not required to consider the impacts of upstream oil development and downstream

oil processing and that every other finding by this Court is entirely unaffected.[1] Petitioners are wrong. To be sure, the Supreme Court held that the Board was not required to consider those upstream and downstream impacts, and that aspect of this Court's decision was undoubtably reversed. But as noted above, the Supreme Court more fundamentally held that "[t]he bedrock principle of judicial review in NEPA cases can be stated in one word: Deference." *Id.* at 1515; *see also* 1510 (finding that the Board was not afforded "the substantial deference required in NEPA cases"). The Supreme Court's broad deference directive clearly applies to judicial review of all claims under NEPA, including Petitioners' claims regarding downline impacts. Moreover, Petitioners' premise does not recognize that this Court's NEPA findings, including those that were reversed, formed a significant part of the basis for its findings under the ICC Termination Act of 1995 (ICCTA) and the Endangered Species Act (ESA) and that the NEPA findings were the primary reason that the Court vacated the Board's decision. When Petitioners' faulty premise is corrected, Petitioners' vacatur argument becomes untenable.

Also of particular relevance here, *Seven County* made clear that "[e]ven if an EIS falls short in some respects, that deficiency may not necessarily require a court

[1] *See, e.g.*, CBD Cross-Motion at 1 (*Seven County* decision is limited to "a single issue"); Eagle County Cross-Motion at 2 (the Court's other findings "remain untouched"), 4 (*Seven County* only "addressed one discrete NEPA issue"), at 20 ("nothing in *Seven County*" "touches on this Court's ICCT Act holdings").

to vacate the agency's ultimate approval of a project, at least absent reason to believe that the agency might disapprove the project if it added more to the EIS." *Seven Cnty.*, 145 S. Ct. at 1514. The Supreme Court itself gave no such reason. Indeed, an overarching theme of the Supreme Court's decision was concern that NEPA-related litigation and delay has led to "fewer" infrastructure projects being built, including "fewer and more expensive railroads." *Id.* at 1513-14.

For these reasons, any remand to the Board should be without vacatur.

A. Seven County *Alters Judicial Review of the Board's Downline Impacts Analysis*

Petitioners mischaracterize *Seven County*, which was an expansive decision. Far from addressing "one discrete issue," (Eagle County Cross-Motion at 4), the Supreme Court based its analysis on the problem that the NEPA "acorn has grown over the years into a judicial oak that has hindered infrastructure development 'under the guise' of just a little more process." *Seven Cnty.*, 145 S. Ct. at 1514 (quotation omitted). As a result, the Supreme Court concluded, a "*course correction* of sorts is appropriate to bring judicial review under NEPA back in line with the statutory text and common sense."[2] *Id.* at 1514 (emphasis added). To

[2] The Supreme Court further observed that Congress did not intend for NEPA – a procedural statute – to be "transformed from a modest procedural requirement into a blunt and haphazard tool employed by project opponents" to stop infrastructure projects they do not like. *Seven Cnty.*, 145 S.Ct. at 1513.

implement that course correction, the Supreme Court confirmed that the "central principle of judicial review in NEPA cases is deference." *Id.* at 1511.

In providing guidance on the deference owed, the Supreme Court recognized that "[a]n agency must make predictive and scientific judgments in assessing the relevant impacts (what are the likely impacts; do they rise to the level of "significant"?)" and held that "[b]lack-letter administrative law instructs that when an agency makes those kinds of speculative assessments or predictive or scientific judgments, and decides what qualifies as significant or feasible or the like, a reviewing court must be at its most deferential." *Id.* at 1512 (quoting, *Baltimore Gas & Elec. Co. v. Natural Resources Defense Council Inc.*, 462 U.S. 87, 103 (1983)). The Court "tie[d] all of this together" by stating that, "[w]hen assessing significant environmental effects and feasible alternatives for the purposes of NEPA, an agency will invariably make a series of fact-dependent, context-specific, and policy-laden choices about the depth and breadth of its inquiry—and also about the length, content, and level of detail of the resulting EIS," and that these choices must be afforded "substantial deference." *Id.* at 1513.

Nothing in *Seven County* even remotely suggests that these broad directives do not apply to all NEPA issues, including this Court's consideration of indirect downline impacts. Rather, the mandate for deference to the agency on its decisions regarding its significance determinations, scientific judgments, and lines drawn

with respect to the depth and breadth of analysis of indirect impacts have readily apparent implications for this Court on remand. The Supreme Court's holding that agencies have "broad latitude" about "how far to go in considering indirect environmental effects from the project at hand," *id.*, also speaks to the Board's analysis of indirect downline effects, including the extent to which the Board studied the risks of rail accidents, wildfires, and distant impacts to the Colorado River along the already-existing Union Pacific Line. Petitioners' unequivocal assumption that, when viewed through the lens of increased deference and as part of any course correction, this Court would not potentially come to a different conclusion, ignores a key holding of the *Seven County* decision.[3]

[3] In addition, while the Board's evaluation of downline impacts was not explicitly addressed by the majority in *Seven County*, the Supreme Court stated that NEPA "required the Board to consider the environmental effects of [the] 88-mile railroad line's construction and operation" and "consistent with NEPA, the Board here *did* comprehensively evaluate those effects." *Id.* at 1516-17 (emphasis in original). Further, *Seven County* concludes that the "proper judicial approach for NEPA cases is straightforward: Courts should review an agency's EIS to check that it addresses the environmental effects of the project at hand." *Id.* at 1518. Given the Supreme Court's awareness of the downline issues, its unqualified endorsement of the Board's required analysis (*i.e.*, review of the "project at hand") and the deferential standard of review, it is reasonable to posit that this Court's finding on the downline issue would not have withstood scrutiny before the Supreme Court.

B. The Supreme Court's Reversal Undercuts This Court's Findings Regarding the ICCTA and ESA

The Supreme Court's holdings regarding NEPA also impact this Court's findings under the ICCTA. For starters, the Board is not "required to weigh"[4] upstream and downstream impacts from oil development, refining, and combustion because the Board had no obligation to study those under NEPA. The Supreme Court's exclusion of these impacts from the Board's NEPA obligation also calls into question what more, if anything, the Board must consider with respect to energy conservation. In addition, the Board's consideration of downline impacts affects the scope of its review under the ESA, as well as how they are weighed under the ICCTA. The Supreme Court's NEPA-related determinations unquestionably impact the other aspects of this Court's decision.

In finding that the Board did not comply with the ICCTA, *Eagle County* found that the Board's ICCTA analysis was necessarily flawed because the EIS failed to consider certain "incredibly significant [upstream and downstream] environmental impacts": specifically, the expansion of oil development in the Uinta Basin, the effect of oil processing on Gulf Coast communities, and the climate effects of the combustion of the oil carried by the new rail line. *Eagle Cnty.*, 82 F.4th at 1194. It went on to hold that the Board "was required not only to

[4] *Eagle County, Colo. v. Surface Transp. Bd.*, 82 F.4th 1152, 1194 (D.C. Cir. 2023) (*Eagle County*).

identify those effects under NEPA . . . but also to weigh them in its ICCT Act analysis" and that "[i]ts failure to do so contributes to our conclusion that the Board's order is arbitrary and capricious." *Id.* But the Supreme Court has since made clear that the "Board did not need to evaluate potential environmental impacts of the separate upstream and downstream projects." *Seven Cnty.*, 145 S. Ct. at 1518.[5] Petitioners' suggestion that excising these "incredibly significant" environmental impacts from this Court's findings related to the ICCTA can have no impact on remand strains credulity.

Further, in faulting the Board for not expressly considering the Rail Transportation Policy factor of energy conservation, *Eagle County* appears to have based its finding, at least in part, on the Board not having more fully considered the upstream and downstream impacts in the general weighing of the transportation merits. *Id.* at 1194-95. Untethered from the upstream and downstream issue, it is

[5] Eagle County appears to be arguing that the Board may have been obligated to consider the upstream and downstream impacts from oil development and oil processing as part of its consideration of the transportation merits even though those are separate projects, are not subject to the Board's jurisdiction, and that the Board was not required to even consider them under NEPA. The County points to no authority for such a stretch of the Board's consideration of the transportation merits of a rail project. Moreover, such a claim disregards *Seven County's* observation that "[r]ailroad lines approved by the Board cannot decline to provide 'common carrier' transport based on the product or commodity to be carried," and for that additional reason, the Board was "'not required to analyze impacts related to the destinations or end uses of any such products or commodities.'" *Seven Cnty.*, 145 S. Ct. at 1518 n.6 (quoting EIS at 422.)

unclear what the Court determined the Board should have considered under that factor, if anything, that would not relate to fossil fuels, their upstream production, and their downstream combustion. *See Seven Cnty.*, 145 S. Ct. at 1524 (Sotomayor, concurring) (explaining that "not one [of the Rail Transportation Policies] concerns the anticipated use of commodities that will be transported on the proposed railway" (citing 49 U.S.C. §10101(1)-(15)). In general, the Board's consideration of energy conservation under the Rail Transportation Policy looks at truck to rail diversion, and, sometimes, fuel efficiency in locomotives (both of which were considered in the EIS here).[6] As such, the focus under the energy conservation policy has been on whether and to what extent the project promotes the more efficient use of energy resources.

Moreover, this Court's criticism that the Board arbitrarily narrowed the scope of ESA review was predicated on its finding that the Board, when studying downline impacts under NEPA, improperly concluded that the risk of spills was so low that it did not justify further study. *Eagle Cnty.*, 82 F.4th at 1187-88. But *Seven County* has called both criticisms into question, as the Supreme Court has

[6] *See e.g. Savage Tooele Railroad Co.—Construction and Operation Exemption—Line of Railroad in Tooele County, Utah,* FD 366316, slip op. at 3 (April 1, 2024); *CSX Corp. and CSX Transportation, Inc., et al.—Control and Merger—Pan Am Systems, et al.,* FD 36472, slip op. at 34 (April 14, 2022); *Stefan Soloviev, Executor, Estate of Sheldon H. Solow—Continuance in Control Exemption—Colorado Pacific San Luis Railroad LLC*, FD 36795, slip op. at 2 (Nov. 21, 2024).

since confirmed that such predictive judgments are entitled to "substantial deference." *Seven Cnty.*, 145 S. Ct. at 1512.

And the Court's ESA conclusion was not the primary reason that it vacated the Board's decision. The Court vacated the Board's decision primarily based on the "numerous NEPA violations arising from the EIS." *Eagle Cnty.,* 82 F.4th at 1196. Certainly, the Court noted that the EIS was "further called into question" because the Biological Opinion failed to assess downline impacts on listed fishes, but the Court made clear that its decision to vacate the Board's decision turned primarily on the NEPA violations. *Id*.

It is also not necessary to separately vacate the Biological Opinion. The Biological Opinion is an input into the Board's decision making; it does not authorize the project. On remand, FWS and the Board will address this Court's ESA conclusions, and then the Board will assess whether the revised Biological Opinion has an impact on its action here.

Likewise, any reassessment by this Court of the Board's or FWS's analysis of downline impacts will be governed by the Supreme Court's instruction that courts should be at their "most deferential" when reviewing an agency's "speculative assessments or predictive or scientific judgments" (e.g., the increased risk of a wildfire or a train derailment and its consequences). *Seven Cnty.*, 145 S. Ct. at 1512. Petitioners do not take into account that such reassessment necessarily

would affect the Court's analysis of how the Board considered those impacts under the ICCTA and how FWS considered the impacts under the ESA.

Because the Court's findings with respect to violations of the ICCTA and ESA are inextricably intertwined with its NEPA analysis, *Seven County* undoubtedly affects the Court's conclusions relating to the ICCTA and ESA. Indeed, apart from this Court's issues with the Board's financial viability analysis, it is unclear whether any remaining concerns continue to be sufficient to support a finding of a violation of the ICCTA or ESA, contrary to Petitioners' overbroad arguments. Clearly, and contrary to Petitioners' claims, the impact of the Supreme Court's findings in *Seven County* is not limited to a single, discrete issue with no impact on this Court's other conclusions.

C. Explanation Could Remedy Some or All of Eagle County's *Findings of Error*

Petitioners' assertion that none of the flaws found by this Court can be remedied on remand by further explanation is unsupported and ignores this Court's own findings.

Indeed, this Court expressed the need for a "more fulsome explanation for the Board's conclusions that the Railway's transportation benefits outweighed the project's environmental impacts." *Eagle Cnty.*, 82 F.4th at 1195. It also asked the Board to do more to "explain how" certain questions regarding the project's financial viability should be treated under the Board's precedent. *Id.* at 1193. And

with respect to downline impacts, this Court acknowledged that the Board could satisfy NEPA requirements by explaining why better data was not available to assess accident risks and what steps it took to address the unavailability. *Eagle Cnty.*, 82 F.4th at 1182. The Court's determination that the Board's finding with respect to wildfire risk and risks to the Colorado River was flawed was based in part on its conclusion that the Board had underestimated accident risk. *Id.* at 1184, 1188. As a result, there are clearly additional issues that could be resolved upon remand with additional explanation by the Board.

In any event, *Seven County* itself provides an additional basis to conclude that additional explanation by the Board on any remand could indeed satisfy NEPA. As noted above, the Supreme Court has made clear that agencies have "broad latitude" in determining "how far to go" in assessing indirect impacts. *Seven Cnty.*, 145 S. Ct. at 1513. In making the necessary "series of fact-dependent, context-specific, and policy-laden choices about the breadth and depth of its inquiry" the Board has discretion to determine, with appropriate explanation, that additional analysis is not necessary "based on the usefulness of [that information] to the decisionmaking process." *Id.* at 1512.

D. Remand Without Vacatur is Appropriate

The Supreme Court's *Seven County* decision is not limited to a single, discrete issue under NEPA. Rather, it informs almost every issue on which this

Court based its vacatur of the Board's decision. Moreover, the Petitioners' insistence that vacatur is required ignores the Supreme Court's observation that "[e]ven if an EIS falls short in some respects, that deficiency may not necessarily require a court to vacate the agency's ultimate approval of a project, at least absent reason to believe that the agency might disapprove the project if it added more to the EIS." *Id.* at 1514. That is so regardless of what the normal remedy may have been in the D.C. Circuit prior to *Seven County*. (CBD Cross-Motion at 20; Eagle County Cross-Motion at 1, 2, 4, 6.)

Therefore, for the reasons stated above and in the Federal Respondents Response to Intervenors' Motion for Remand Without Vacatur, the Court should grant Intervenors Motion for Remand Without Vacatur and deny the Petitioners' Cross-Motions.

Respectfully submitted,

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Dated: August 8, 2025

CERTIFICATE OF COMPLIANCE

This document complies with the type-volume limit of Federal Rule of Appellate Procedure 27(d)(2)(A) because this document contains 2,945 words.

This document complies with the typeface and type-style requirements of Federal Rule of Appellate Procedure 27(d)(1)(E) because this document has been prepared in a proportionally spaced typeface using Microsoft Word 365 in 14-point Times New Roman font.

/s/ *Barbara A. Miller*
Counsel for Respondent the
Surface Transportation Board

EXHIBIT 33

DECLARATION OF KARA CLAUSER

I, Kara Clauser, declare as follows:

1. The facts set forth in this declaration are based on my personal knowledge. If called as a witness in these proceedings, I could and would testify competently to these facts. As to those matters which reflect an opinion, they reflect my personal opinion and judgment on the matter.

2. I am a Geographic Information System (GIS) specialist at the Center for Biological Diversity (Center), and I have worked in this capacity for over five years. I hold a Bachelor of Science from the University of Arizona in Ecology and Evolutionary Biology and a Master of Science from the University of Arizona in Geographic Information Systems Technology. I have training in several GIS software applications and have over seven years of experience in GIS analysis and cartography.

3. I prepared the map, attached as Attachment A to this Declaration, depicting the Union Pacific rail line between Kyune, Utah and Granby, Colorado.

4. To prepare the maps, I used ArcGIS Pro version 3.0.2 from Environmental Systems Research Institute (ESRI). In my professional opinion, it is accurate with respect to the data it represents.

5. To map the Union Pacific rail line, I used the "Union Pacific Railroad" feature layer from the National Rail Network Map, available as an

ArcGIS online webmap here: https://www.arcgis.com/home/item.html?id=96ec03e4fc8546bd8a864e39a2c3fc41. This webmap shows the extent and ownership of rail lines in the United States using data obtained from the National Transportation Atlas Database (NTAD). From this layer, I extracted the segment of the Union Pacific rail line that connects Kyune, Utah to Granby, Colorado and calculated its length to be 384 miles using ESRI's "Calculate Geometry" data management tool.

6. I downloaded U.S. Geological Survey's National Hydrography dataset here: https://apps.nationalmap.gov/downloader/#/ for the state of Colorado. I queried the "Flowline" layer to display only the Colorado River. I also downloaded the U.S. Fish and Wildlife Service's critical habitats database here: https://ecos.fws.gov/ecp/report/critical-habitat, and queried it to display only final critical habitats for humpback chub, bonytail chub, razorback sucker, and Colorado pikeminnow.

7. To calculate the length of rail line that roughly parallels the Colorado River, I used ESRI's Editing tools to clip the Kyune to Granby Union Pacific rail line segment starting to the west at the first point the river approaches the tracks west of the Utah – Colorado border (39.091673, -109.102654) and ending east where the tracks branch east away from the river near Granby, Colorado

(40.097482, -105.974517). Using the "Calculate Geometry" tool I determined the length of this segment to be 233 miles.

8. To calculate the length of rail line paralleling Colorado River fish critical habitats, I repeated the steps in paragraph 7 using the same starting point to the west (39.091673, -109.102654) and this time ending east where the Colorado River critical habitats end near Rifle, Colorado (39.528390, -107.777401). Using the "Calculate Geometry" tool I determined the length of this segment to be 100 miles.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge, information, and belief.

Executed this 17th day of February, 2023,



Kara Clauser

ATTACHMENT A

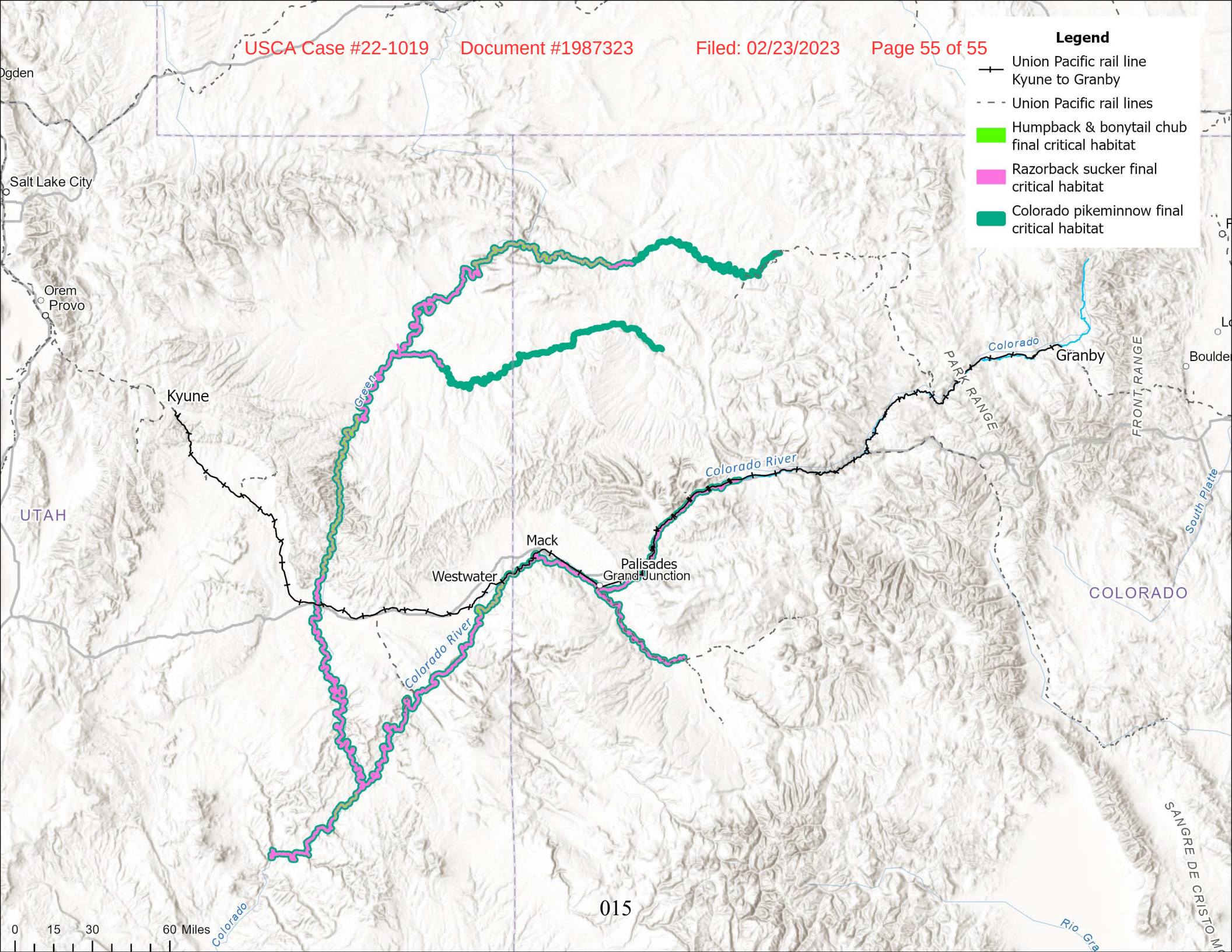

Legend
Union Pacific rail line Kyune to Granby
Union Pacific rail lines
Humpback & bonytail chub final critical habitat
Razorback sucker final critical habitat
Colorado pikeminnow final critical habitat
Ogden
Salt Lake City
Orem
Provo
Kyune
Green
Colorado
Granby
PARK RANGE
FRONT RANGE
Boulder
Colorado River
South Platte
UTAH
Mack
Westwater
Palisades
Grand Junction
COLORADO
Colorado River
SANGRE DE CRISTO
0 15 30 60 Miles

EXHIBIT 34

5- Year Review Short Form

Species Reviewed:

Bonytail (*Gila elegans*)

Federal Register Notice Announcing Initiation of this Review:

May 27, 2016. Endangered and threatened wildlife and plants; 5-year status reviews of 21 species in the Mountain Prairie Region (81 FR 33698).

Lead Region:

Region 6, Upper Colorado River Endangered Fish Recovery Program, Tom Chart, Director, 303–236–9885.

Current Classification:

Endangered

Current Recovery Priority Number:

5C. This recovery priority number is indicative of a species facing a high degree of threat; has a low recovery potential; is listed at the species level; and there is the potential for conflicts between needed recovery actions and economic activities.

Methodology used to complete this review:

This review was completed by the Upper Colorado River Endangered Fish Recovery Program (UCREFRP) Office in cooperation with Region 2, on June 27, 2019. All pertinent literature and documents on file at the UCREFRP Office were used for this review, with specific emphasis on new information obtained since 2012. New information included increasing evidence of survival of stocked fish and limited evidence of natural reproduction; however, new information did not alter our understanding of the species status and threats per the analyses contained in the most recent status review (USFWS 2012).

Review Summary:

The bonytail is a fish species endemic to warm-water habitats of the Colorado River and its tributaries. The species was historically widespread and common from Mexico to Wyoming, but by the late 1970s had declined to less than 50 known individuals. The U.S. Fish and Wildlife Service (Service) originally listed bonytail as an endangered species in 1980 under the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq*.), citing extirpation from most of its range in the Colorado River Basin due to habitat alteration (45 FR 27710; April 23, 1980). The decline of bonytail populations, likely beginning in the 1950s, was largely undocumented prior to the last wild individuals being brought into captivity. Because the species became functionally extinct prior to extensive sampling efforts, the ecology of the bonytail, including habitat preferences, is largely unknown (USFWS 2002; Lower Colorado River Multi-Species Conservation Program 2016). Large mainstem dams, water diversions, habitat modification, nonnative fish species, and degraded water quality that caused population declines of other native fishes in the Colorado River likely also affected bonytail (Miller 1961; Minckley and Deacon 1991).

Review Summary (continued):

Glen Canyon Dam physically separates bonytail populations into two recovery units, the upper and lower basins. Two management programs, the Upper Colorado River Endangered Fish Recovery Program (UCREFRP) in the upper basin and the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) in the lower basin undertake the majority of management actions for the conservation of the species, including stocking, flow management, nonnative fish removal, and habitat development. Despite management efforts, signs of bonytail survival in the wild remain rare and the ecology of the species remains poorly understood.

Without viable, wild bonytail populations, the species continues to rely on hatchery propagation to persist in the wild and advance recovery efforts. The founder population of 10 individuals used for hatchery broodstock was captured from Lake Mohave between 1976 and 1978 (USFWS 2002). Hatcheries in the upper basin produce and stock over 35,000 adult bonytail per year into upper basin rivers, including the Green, White, Yampa, Dolores, Gunnison, San Rafael, Price, and Colorado rivers (UCREFRP Integrated Stocking Plan Revision Committee 2015). In the lower basin, hatcheries produce and stock over 13,000 adult bonytail per year into several reaches, and backwaters, of the lower Colorado River (LCR MSCP 2015). The Programs successfully maintain genetic diversity and refuge populations of the species. However, when hatchery reared individuals are stocked into the wild, survival rates are extremely low, and therefore the viability of bonytail populations remain low.

The 2002 recovery goals for bonytail identified the alteration of habitat (flow regimes, water temperature, physical habitat and barriers reducing connectivity; Factor A) and the presence of nonnative species (Factor C) as significant threats to the species. Management actions through two conservation programs continue to address these identified threats (Factor D), but the lack of viable bonytail populations in the wild and ongoing threats continue to influence the condition of the species. Habitat alteration and nonnative predators remain threats to the bonytail. Overutilization (Factor B), diseases and parasites (Factor C) were not identified as substantial threats to the species. The present levels of hybridization among *Gila* species is not considered a threat to the species, but will be re-evaluated as *Gila* species populations increase to determine impacts (USFWS 2012). Hybridization likely was common historically between the Colorado River *Gila* species, with the presence of a few bonytail haplotypes found among all upper basin humpback chub (*Gila cypha*) populations (Bohn *et al*. 2018). The effects of pollutants remains somewhat unknown but the imminent threat of potential spills or leaching of environmental contaminants still remain high for bonytail (Factor E). Below we summarize new information that has become available since the most recent status review, our last 5-year review for the species (USFWS 2012).

Although augmentation has been occurring for decades, survival of stocked bonytail in the upper basin remains very low, with documented survival rates of approximately 2 percent (UCREFRP Biology Committee 2017). Post-stocking survival is documented each time a fish is "encountered," either through physical handling or passive interaction with antennas placed in the river. Encounters with stocked bonytail are increasing, with 11,113 individuals, or approximately 5 percent of the bonytail stocked since 2012, encountered (*i.e.* captured, detected, or transferred) (STReaMS 2019). It is currently unknown as to whether the increase in encounters is because populations are increasing or because technology to detect them has

Review Summary (continued):
improved. While both active and passive sampling for bonytail occur, 95 percent of the encounters are PIT tag antenna detections (UCREFRP Biology Committee 2017; STReaMS 2019). In the lower basin, survival of hatchery released bonytail also remains low in natural systems, with less than 4 percent survival beyond 30 days post-release between 2007 and 2017 (McCall *et al.* 2017). This data suggests that a very small percentage of stocked bonytail survive long-term in the mainstem of the Colorado River. The LCR MSCP manages three isolated backwaters where bonytail are recruiting and are likely self-sustaining, including High Levee Pond, Imperial Ponds and Davis Cove backwater (J. Newton, personal communication 2019). All three locations are managed specifically for bonytail and nonnative fish species are excluded.

Despite natural reproduction within the upper and lower basins in some managed floodplain wetlands and backwater habitat (Bestgen et al. 2017, LCR MSCP 2018), survival of larval bonytail has not been observed and no young-of-year or juvenile fish have ever been found in the rivers of the Colorado River basin. No self-sustaining populations in the rivers of the upper or lower basins have been established.

Recommendations on species status:

After reviewing the best available scientific information, we conclude that the bonytail remains an endangered species. Our review of new information compiled since 2012 does not change our evaluation of species status and the threats affecting the species under the factors in 4(a)(1) of the Act from our most recent review of the species (USFWS 2012). Specifically, the continuing lack of any viable populations in the wild, low rates of survival for stocked fish, and ongoing threats associated with habitat alteration, predation by nonnative fish, and potential spills or leaching of environmental contaminants supports our previous evaluation that the bonytail remains in danger of extinction across its entire range and thus continues to meet the definition of an endangered species under the Act. Therefore, we recommend no change in status to the species at this time.

Recommended future actions:

Additional research providing a better understanding of how habitat alternations, diseases and parasites, nonnative fishes, and potential contaminants affect the physical condition, survival, and reproduction of bonytail could further facilitate this species' recovery. Intensive management remains necessary in order to facilitate this species' recovery.

Based on our experience managing the other Colorado River fish, the suite of threat management actions identified in the 2002 Bonytail Recovery Goals still provide managers with reasonable guidance until more species-specific information is identified. Similarly, we have not gathered compelling information to recommend revising the demographic criteria in those goals. Therefore, we do not recommend revising the Bonytail Recovery Plan at this time and will reevaluate the need for revision at the time of the next 5-year review.

Approve: Tom Chart **Date:** 6/27/19

Tom Chart, Director
Upper Colorado River Endangered Fish Recovery Program

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Newton, J. 2019. Project Leader, Arizona Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service, Flagstaff, AZ.

EXHIBIT 35

Bonytail
(Gila elegans)

5-Year Review:
Summary and Evaluation



Illustration by: Joseph R. Tomelleri; used with permission

U.S. Fish and Wildlife Service
Upper Colorado River Endangered Fish Recovery Program
Denver, Colorado

July 2012

5-YEAR REVIEW
Species reviewed: Bonytail (*Gila elegans*)

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5-YEAR REVIEW
Bonytail/*Gila elegans*

1.0 GENERAL INFORMATION

1.1 Purpose of 5-year Reviews

The U.S. Fish and Wildlife Service (Service) is required by Section 4(c)(2) of the Endangered Species Act (ESA) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in Section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.2 Reviewers

Lead Regional Office: Mountain-Prairie Region (6)
Michael Thabault, Assistant Regional Director-Ecological Services, 303/236-4210
Bridget Fahey, Chief-Endangered Species, 303/236-4258
Seth Willey, Regional Recovery Coordinator, 303/236-4257

Lead Field Office:
Upper Colorado River Endangered Fish Recovery Program
Thomas Chart, Program Director, 303/969-7322 ext. 226

Cooperating Field Offices:
Ecological Services Field Sub-Office, Grand Junction, Colorado
Patty Gelatt, Assistant Field Supervisor, 970/243-2778

Colorado River Fisheries Program, Grand Junction, Colorado
Dale Ryden, Field Supervisor, 970/245-9319 ext.19

Utah Ecological Services Field Office, Salt Lake City, Utah
Larry Crist, Field Supervisor, 801/975-3330 ext. 126

Wyoming Ecological Services Field Office, Cheyenne, Wyoming
Mark Sattelberg, Field Supervisor, 307/772-2374 ext. 34

Arizona Fish and Wildlife Conservation Office, Whiteriver, Arizona
Stewart Jacks, Field Supervisor, 928/338-4288

Lower Colorado River Coordinator, Phoenix, Arizona
Sam Spiller, Coordinator, 602/242-0210 ext. 240

Arizona Ecological Services Office, Phoenix, Arizona
Steve Spangle, Field Supervisor, 602/242-0210 ext. 244

Nevada Fish and Wildlife Office, Reno, Nevada
Ted Koch, Field Supervisor, 775/861-6331

Cooperating Regional Offices:
Southwest Region (Region 2)
Michelle Shaughnessy, Assistant Regional Director-Ecological Services, 505/248-6920
Susan Jacobsen, Chief-Endangered Species, 505/248-6641
Wendy Brown, Regional Recovery Coordinator, 505/248-6664

Pacific Southwest Region (Region 8)
Michael Fris, Assistant Regional Director-Ecological Services, 916/414-6464
Michael Long, Chief-Listing, Recovery & Environmental Contaminants, 916/414-6478
Larry Rabin, Deputy Chief-Listing, Recovery & Environmental Contaminants, 916/414-6464

1.3 Methodology Used to Complete the Review

On April 18, 2007, we published a Notice of Review in the Federal Register (72 FR 19549) soliciting any new information on the bonytail that may have a bearing on its classification as endangered or threatened. Fewer than 20 people/agencies provided comments. All substantive comments and issues raised were considered. This 5-year review was primarily written by the Upper Colorado River Endangered Fish Recovery Program (UCREFRP) Office with substantive contributions and review by cooperating field and regional offices. It summarizes and evaluates information provided in the recovery goals, current scientific research, and surveys related to the species. All pertinent literature and documents on file at the UCREFRP Office were used for this review (see References section below for cited documents). Interviews with individuals familiar with bonytail were conducted as needed to clarify or obtain specific information.

1.4 Background

1.4.1 Federal Register Notice Citation Announcing Initiation of This Review

72 FR 19549; April 18, 2007

1.4.2 Listing History

Original Listing
FR notice: 45 FR 27710
Date listed: April 23, 1980
Entity listed: Chub, bonytail; *Gila elegans*
Classification: Endangered rangewide

1.4.3 Associated Rulemakings

59 FR 13374; March 21, 1994 - Critical Habitat Designated

1.4.4 Review History

Historic 5-year reviews for all species, including bonytail, were initiated by the Service's Washington, D.C. office in 1985, and 1991 (50 FR 29901, July 22, 1985; 56 FR 56882, November 6, 1991). The bonytail's status also was considered in the 1990 recovery plan and 2002 recovery goals (Service 1990; 2002).

1.4.5 Species' Recovery Priority Number at Start of 5-year Review:

The bonytail has a recovery priority number (RPN) of 5C. This rank indicates that the bonytail: faces a high degree of threat; has a low recovery potential; is listed at the species level; and there is the potential for conflicts between needed recovery actions and economic activities (see TABLE 1 below).

1.4.6 Recovery Plan

Name of plan: Bonytail (*Gila elegans*) Recovery Goals: amendment and supplement to the Bonytail Chub Recovery Plan.

Date approved: August 1, 2002

Dates of previous revisions, if applicable: September 4, 1990

TABLE 1. Recovery Priority Numbers Ranking System. The above ranking system for determining RPNs was established in 1983 (48 FR 43098, September 21, 1983, as corrected in 48 FR 51985, November 15, 1983).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment Policy

This section of the 5-year review is not applicable to this species because the bonytail was not listed as a Distinct Population Segment (DPS) nor is there relevant new information for this species regarding the application of the DPS policy. For the time being, we believe continued listing at the species level is the most appropriate way to manage this listed species under the ESA. This issue will be further evaluated in the recovery plan, including consideration of whether potential DPSs could be delisted independently once recovery is achieved in each unit.

2.2 Recovery Criteria

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Bonytail recovery is planned to occur basinwide within the Colorado River basin, but Glen Canyon Dam separates the upper and lower basins into two recovery units. Three programs in the Colorado River Basin are working to recover or conserve bonytail. The UCREFRP is a coordinated effort of State and Federal agencies, water users, energy distributors, and environmental groups to recover four endangered fishes in the upper basin downstream to Glen Canyon Dam, excluding the San Juan River. The Native Fish Work Group is a conservation program coordinating efforts of State and Federal agency biologists, as well as university staffs and volunteers, to conserve and protect bonytail. The Lower Colorado River Multi-Species Conservation Program (LCRMSCP) is a conservation program aimed at protecting sensitive, threatened, and endangered species of fish, wildlife, and their habitat. The bonytail is one of many species covered by this program.

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X_ Yes

____ No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

___ Yes
_X_ No

We recommend revising the Service's 2002 bonytail recovery goals (2002) to more clearly recognize that re-established populations will likely fluctuate in the abundance of adults over time. The Service also should re-evaluate repatriation stocking efforts and the results of recent research / monitoring to better understand the effectiveness of recovery actions.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

_X_ Yes
___ No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.

The current status of bonytail is endangered. Only the downlisting criteria are considered in this 5-year status review to determine if status can be changed (downlisted) from endangered to threatened. The delisting criteria will be used when the species is removed from the list, i.e., from threatened to recovered. Analysis of each criterion is provided in italics directly below the criterion. Recovery of the species is considered basinwide, where re-established populations are being developed. The downlisting recovery criteria are from the 2002 revision to the species' recovery goals (Service 2002).

DEMOGRAPHIC DOWNLISTING CRITERIA FOR BONYTAIL

Bonytail were once widespread throughout the Colorado River and its tributaries. Currently, no self-sustaining populations of bonytail exist in the wild, and few individuals have been caught throughout the basin.

Upper Basin Recovery Unit Criterion 1a. In the Green River Subbasin, a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service,[1] such that the trend in adult (age 4+; ≥250 millimeters [mm] total length [TL]) point estimates does not decline significantly.

[1] The accuracy and precision of each point estimate will be assessed by the Service in cooperation with the respective recovery or conservation programs, and in consultation with investigators conducting the point estimates and with qualified statisticians and population ecologists.

Status of Upper Basin Recovery Unit Criterion 1a. This criterion has not been met. *While stocking has been occurring for over a decade, no self-sustaining population has been established.*

Upper Basin Recovery Unit Criterion 1b. In the Green River Subbasin a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality.

Status of Upper Basin Recovery Unit Criterion 1b. This criterion has not been met. *While augmentation has been occurring for over a decade, recruitment of age-3 fish to adult (age-4) has not been realized; therefore, the population is not considered self-sustaining.*

Upper Basin Recovery Unit Criterion 1c. In the Green River Subbasin, a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that each point estimate exceeds 4,400 adults (Note: 4,400 is the estimated minimum viable population [MVP] number).

Status of Upper Basin Recovery Unit Criterion 1c. This criterion has not been met. *While augmentation has been occurring for over a decade, the recapture of stocked fish has been small. Tagged fish have been detected where remote PIT-tag antennas operate, such as the Stirrup floodplain in the middle Green River and Price-Stubb fish ladder on the upper Colorado River, which demonstrates that survival of stocked fish is occurring. Fish that have been recently stocked are often encountered through other projects, some of these have had heavy Lernea or fungal infections (Bestgen et al. 2008). However, too few fish have been captured to estimate the population size. Based on these surveys, it is reasonable to assume we have a population well below 4,400 adults.*

Upper Basin Recovery Unit Criterion 2a. In the Upper Colorado River Subbasin a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that the trend in adult (age 4+; ≥250 mm TL) point estimates does not decline significantly.

Status of Upper Basin Recovery Unit Criterion 2a. This criterion has not been met. *While augmentation has been occurring for over a decade, no self-sustaining population has been established.*

Upper Basin Recovery Unit Criterion 2b. In the Upper Colorado River Subbasin a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality.

Status of Upper Basin Recovery Unit Criterion 2b. This criterion has not been met. *While augmentation has been occurring for over a decade, recruitment of age-3 fish to adult (age-4) has not been realized; therefore, the population is not considered self-sustaining.*

Upper Basin Recovery Unit Criterion 2c. In the Upper Colorado River Subbasin, a self-sustaining population is maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that each point estimate exceeds 4,400 adults (MVP).

Status of Upper Basin Recovery Unit Criterion 2c. This criterion has not been met. *While augmentation has been occurring for over a decade, the recapture of stocked fish has been small. As many as 22 individuals have been captured at selective fish ladders in the Upper Colorado River Subbasin (Burdick 2011a). Unfortunately, too few fish have been captured to estimate population size.*

Lower Basin Recovery Unit Criterion 1. Genetic variability of bonytail is identified and a genetic refuge (e.g., in Lake Mohave, Lake Havasu, or other suitable locations) is maintained over a 5-year period.

Status of Lower Basin Recovery Unit Criterion 1. This criterion has been met. *Dexter National Fish Hatchery and Technology Center maintains a genetic refuge for bonytail. Production of bonytail for repatriations into the upper and lower basins is done under a draft genetic management plan (Service 2004). A second broodstock has been authorized and will be developed over the next several years, as a precaution against a catastrophic event that may destroy the primary broodstock.*

Lower Basin Recovery Unit Criterion 2a. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population the trend in adult (age 4+; ≥ 250 mm TL) point estimates does not decline significantly.

Status of Lower Basin Recovery Unit Criterion 2a. This criterion has not been met. *While augmentation has been occurring in several reaches of the Lower Colorado River, no self-sustaining population has been established. Attempts are being made to re-establish bonytail populations in reaches 2 (Lake Mohave), 3 (Lake Havasu) and 4/5 (Parker Dam to Imperial Dam). In addition, rearing ponds located adjacent to Lakes Mohave and Havasu are being used to grow fish to larger sizes prior to stocking. Efforts are showing a small success in Lake Havasu following telemetry studies (LCRMSCP 2011) and reports of angler captures of bonytail (Fitzpatrick 2011, pers. comm.).*

Lower Basin Recovery Unit Criterion 2b. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population mean estimated recruitment of age-3 (150–249 mm TL) naturally produced fish equals or exceeds mean annual adult mortality.

Status of Lower Basin Recovery Unit Criterion 2b. This criterion has not been met. *While augmentation has been occurring, recruitment of age-3 (to adult age-4) fish has not been realized (Mueller et al. 2005). Therefore, no self-sustaining populations exist in the Lower Basin Recovery Unit.*

Lower Basin Recovery Unit Criterion 2c. Two self-sustaining populations (e.g., mainstem and/or tributaries) are maintained over a 5-year period, starting with the first point estimate acceptable to the Service, such that for each population each point estimate exceeds 4,400 adults (MVP).

Status of Lower Basin Recovery Unit Criterion 2c. This criterion has not been met. *While augmentation has been occurring for many years, the number of stocked fish recaptures remains low.*

RECOVERY FACTOR DOWNLISTING CRITERIA FOR BONYTAIL TO MINIMIZE OR REMOVE THREATS TO THE SPECIES

Upper Basin Recovery Unit

Factor A — Adequate habitat and range for recovered populations is provided. It is believed that bonytail once inhabited the larger rivers of the Colorado River Basin from Wyoming and Colorado to northwestern Mexico. The bonytail was reported in decline following a period of dam construction throughout the Colorado River Basin. Cold-water releases downstream of dams have created temperature regimes outside the thermal preferences of bonytail and eliminated turbid conditions that historically provided cover from predators. Seven barriers are identified in the upper basin upstream of Glen Canyon Dam within occupied habitat of bonytail. Like many of the *Gila* genus, bonytail are thought to migrate to natal spawning areas; therefore, maintenance of streamflow is important to this species' recovery and conservation.

Criterion 1. Flow regimes to benefit bonytail populations in the Green River and Upper Colorado River Subbasins are identified, implemented, evaluated, and revised, such that:

a) Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations.

b) Adequate nursery habitat is available to maintain self-sustaining populations.

c) Adequate juvenile and adult habitat (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations.

Status of Criterion 1. Criterion 1 has been partially met. *Flow recommendations have been developed throughout the Green River Subbasin (Irving et al. 2004 [White River]; Muth et al. 2000 [Green River]; Modde and Keleher 2003 [Duchesne River]; Modde et al. 1999 [Yampa River]); and the Upper Colorado River Subbasin (Osmundson et al. 1995 [15-mile reach]; McAda 2003 [upper Colorado and Gunnison Rivers]). These flow recommendations are being implemented and monitored by the UCREFRP. A Green River study plan has been developed (Green River Study Plan ad hoc Committee 2007) to determine the response of endangered fish to the implemented flow recommendations downstream of Flaming Gorge Dam. The UCREFRP collaborated with the Colorado River Water Conservancy District (District) and the City of Craig, Colorado, on the enlargement of Elkhead Reservoir in the Yampa River drainage and*

thereby secured 5,000 acre-feet of "fish water" (with the option to lease an additional 2,000 acre-feet annually) to augment Yampa River baseflows. Since the enlargement was completed in 2007, the "fish water" has been delivered every year. Although the necessary flows have been identified and implemented, they are still under evaluation and may need to be revised.

Since 1997, the District, Northern Colorado Water Conservancy District, Denver Water, and Bureau of Reclamation have coordinated with the Service to deliver in excess of 1 million acre-feet of water to assist in the recovery of the endangered fish in the 15-mile reach of the Colorado River near Grand Junction during base flow (TABLE 2). These volumes of water have resulted in increased river flows on average of 282 cubic feet per second (cfs) to a maximum of 1,156 cfs during critical low flow and warm temperature periods of late summer.

TABLE 2. Coordinated water releases to benefit endangered fish in the Colorado River, Colorado, 1997–2011.

RESERVOIRS	ACRE-FEET
Windy Gap	3,718
Willow Creek	9,852
Granby	39,914
Palisade Bypass	93,038
Williams Fork	89,342
Wolford Mountain	137,879
Ruedi	272,287
Green Mountain	532,000
Total	**1,178,030**

Criterion 2. Passage over Redlands Diversion and Grand Valley Diversion continues to allow adequate movement of bonytail in the upper Colorado River and Gunnison River.

Status of Criterion 2. Criterion 2 has been met. *A 350-foot long, U-shaped fish passage at the Redlands Water and Power Company Diversion Dam on the Gunnison River was completed in 1996. The passage restored access to 50 miles of critical habitat for the endangered fish. To date, 108 Colorado pikeminnow (Ptychochielus lucius), 27 razorback sucker (Xyrauchen texanus), 1 bonytail, 1 humpback chub (Gila cypha), and over 97,000 other native fish have used the passage (Burdick 2011b).*

A 300-foot long, rock channel fish passage at the Grand Valley Irrigation Company Diversion Dam on the Colorado River became operational in 1998. Unlike the fish passage structure at the Redlands diversion, this fish passage is a "non-selective" passage, meaning that all fish species are allowed to move through it. A gate was installed in 2007 to remotely open and close the passage. The elevation of the pond can be adjusted and adequately maintained at user

selected set-points by adjusting the pressure in the air bladders within the system control range (full inflation to full deflation). These passages continue to be operated and allow adequate movement of bonytail.

Criterion 3. Modify the Price-Stubb Dam and Government Highline Dam to allow adequate movement of bonytail in the upper Colorado River.

Status of Criterion 3. Criterion 3 has been met. *Construction was completed on Price-Stubb Dam of a passive non-selective fish passage structure and began functioning on March 20, 2008.*

Construction of a 373-foot long concrete fish passage at the Grand Valley Project Diversion Dam (also referred to as the Government Highline Dam) on the Colorado River was completed in 2005. The structure provides selective passage for native fish only at this historic dam across the Colorado River. During trial operations in 2005 and 2006, 1 razorback sucker, 3 humpback chubs, and about 14,000 other native fish moved upstream. Beginning in 2008, the passage has operated from the spring through the fall, passing 1 razorback sucker in 2008 and over 37,300 native fish for both years (Burdick 2011a).

Criterion 4. Investigations are initiated on the feasibility of modifying releases from Aspinall Unit dams to increase water temperatures in the Gunnison River that would allow for upstream range expansion of bonytail.

Status of Criterion 4. Criterion 4 has been partially met. *Osmundson (1999) recommended a feasibility study for increasing Gunnison River temperatures near Delta, Colorado, by modification of outlet structures on the Aspinall Unit dams. A 2-phased study completed in 2004 suggested temperature could be modified through the timing of release through Crystal Dam (Hydrosphere Resource Consultants 2001, 2004; Boyer and Cutler 2004). This feasibility study indicated that the installation of a multi-level outlet would be needed at Blue Mesa Reservoir to create a measurable warming effect in the Gunnison River at Delta, Colorado. However, the authors recommended that additional temperature data be collected to address uncertainty associated with their results. Those additional data have been / are being collected. For the time being, the Upper Colorado River Program has determined that the expense of retrofitting Blue Mesa dam with a multi-level outlet is not worth the limited amount of recovery benefit.*

Criterion 5. Measures are identified to minimize entrainment (incidental trapping of fish in waters being diverted for irrigation) of subadult and adult bonytail at problematic diversion structures.

Status of Criterion 5. Criterion 5 has been partially met. *Screens are in place and operated at Grand Valley Irrigation Company (since 2002), Grand Valley Project (since 2004), and Redlands Diversion (since 2007). The Recovery Program is still considering screening the Tusher Wash diversion on the Green River. No other problematic diversion structures are known at this time.*

Criterion 6. Habitats necessary for the establishment and maintenance of bonytail populations in the Green River and upper Colorado River Subbasins are identified.

Status of Criterion 6. Criterion 6 has not been met. *Habitat requirements for bonytail are uncertain. Bonytail are currently being stocked in alluvial reaches of the river and floodplains in an attempt to increase their survival. Recaptures are low from fish stocked in or upstream of canyon habitats. Bottomland sites were identified and either acquired or had easements made in perpetuity. These sites are being managed to benefit the endangered fish (Valdez and Nelson 2004, 2006).*

Factor B — Protection from overutilization for commercial, recreational, scientific, or educational purposes. Overutilization of bonytail for commercial, recreational, scientific, or educational purposes is not currently considered a threat to the species. Bonytail have no commercial or recreational value and are not sought by commercial fishermen or anglers. Collection of bonytail for scientific or educational purposes is regulated by the Service under the ESA.

Criterion 7. Overutilization of bonytail for commercial, recreational, scientific, or educational purposes re-evaluated and, if necessary, actions identified to ensure adequate protection.

Status of Criterion 7. Criterion 7 has been met. *No commercial or recreational activities exist. Scientific activities are minimal and not considered a threat. Educational activities are minimal and do not threaten bonytail.*

Factor C — Adequate protection from diseases and predation. Diseases and parasites are not considered to be significant by themselves in the decline of the bonytail.

A large number of nonnative fishes are found in historic and currently occupied habitat of bonytail. Nonnative species are a major cause for lack of recruitment in bonytail. A Strategic Plan for Nonnative Fish Control was developed for the Upper Colorado River. Control of the release and escapement of nonnative fishes into the main river, floodplain, and tributaries also is a necessary management action to stop the introduction of new fish species into occupied habitats and to thwart periodic escapement of highly predaceous nonnatives from riverside features. Three management actions are identified to reduce the threat of nonnative fishes including: high spring flows to disadvantage spawning activities, nonnative fish control strategies, and stocking agreements. Active control programs should be implemented or continued for problematic nonnative fishes in bonytail nursery habitats (potentially flooded bottomlands), such as small-bodied cyprinids, northern pike (*Esox lucius*) in the middle Green River, and channel catfish (*Ictalurus punctatus*) in river reaches occupied by bonytail.

Criterion 8. Effects of diseases and parasites on bonytail populations are re-evaluated and, if necessary, actions identified to ensure adequate protection.

Status of Criterion 8. Criterion 8 has not been met. *The effects of disease and parasites on bonytail populations have not been re-evaluated. Bestgen et al. (2008) noted many stocked bonytail at large less than 4 months had Lernaea or fungal infections.*

Criterion 9. Procedures are developed, implemented, evaluated, and revised for stocking nonnative fish species in the Upper Colorado River Basin to minimize negative interactions between nonnative fishes and bonytail.

Status of Criterion 9. Criterion 9 has been partially met. *Nonnative fish stocking procedures for the Green River and Colorado River Subbasins were initially developed in 1996 and modified in 2009 (Service 1996; 2009). Colorado Parks and Wildlife intend to implement the revised procedures in 2012. Once implemented, we will need to evaluate the effectiveness in minimizing negative interactions between nonnative fish and bonytail.*

Criterion 10. Control programs for small-bodied nonnative fishes in nursery habitats in river reaches occupied by young bonytail are developed and implemented to identify levels of control that will minimize predation.

Status of Criterion 10. Criterion 10 has been partially met. *Small-bodied cyprinid (e.g., bluegill [Lepomis macrochirus], green sunfish [Lepomis cyanellus], and redear sunfish [Lepomis microlophus]) control studies indicate that reduction in the numbers of small-bodied cyprinids only lasted for a short period of time (Trammel et al. 2004). In a reset floodplain (inundated after dewatering), survival of larval bonytail at high and low densities in the presence of age-0 nonnative fish was 1.7% and 1.3% respectively, while survival in the control enclosure without nonnative fish was 17.1% (Christopherson et al. 2004; Brunson and Christopherson 2005). Growth rates for fish from both densities were 0.8 mm/day. Control through resetting of the floodplain wetland may not always be possible in high water years, therefore, other forms of control should be considered.*

Criterion 11. Channel catfish control programs in river reaches occupied by bonytail are developed and implemented to identify levels of control that will minimize predation.

Status of Criterion 11. Criterion 11 has been partially met. *Various attempts to mechanically remove channel catfish (Fuller 2009; Badame and Jones 2009) in the Upper Colorado River Basin have had minimal effects on channel catfish populations. The Upper Colorado River program has shifted focus to nonnative smallmouth bass and northern pike, which were found to have a larger bioenergetic impact on native fish communities (Johnson et al. 2008).*

Criterion 12. Northern pike control programs in reaches of the Yampa and middle Green Rivers occupied by bonytail are developed and implemented to identify levels of control that will minimize negative interactions.

Status of Criterion 12. Criterion 12 has been partially met. *Interim Yampa River Nonnative Fish Removal Criteria have been developed, and a Yampa River Nonnative Fish Control Strategy (Valdez et al. 2008) is being implemented. A control program for northern pike in the Yampa River was initiated in 1999, and removal of northern pike in the middle Green River was initiated in 2001. Based on trends in catch rates of subsequent years, removal efforts have been successful at significantly reducing the number of northern pike in the middle Green River. Control efforts since 2003 have resulted in the capture of less than 40 northern pike and as a result, total effort was reduced to only a maintenance level beginning in 2005 (Skorupski and*

Breen 2011). Northern pike control in the Yampa and Green Rivers is specifically implemented through four ongoing projects by the UCREFRP. Northern pike are removed whenever encountered during all other UCREFRP projects.

Factor D — Adequate existing regulatory mechanisms. Implementation of regulatory mechanisms is necessary for recovery of the bonytail and to ensure long-term conservation of the species. After removal from the list of threatened and endangered species and from protection by the ESA, the bonytail and its habitat will continue to receive consideration and some protection through the following Federal laws and related State statutes: National Environmental Policy Act; Clean Water Act; Organic Act; and Fish and Wildlife Coordination Act.

The need for conservation plans and agreements is identified in these recovery goals to provide reasonable assurances that recovered bonytail populations will be maintained.

Criterion 13. Mechanisms are determined for legal protection of adequate habitat.

Status of Criterion 13. Criterion 13 has been partially met. *Filing for legal rights to protect water for fish would be junior to the legal rights of others that have already claimed water for irrigation and power. Utah is currently reviewing the water rights from Flaming Gorge Reservoir and how they may be modified for fish protection. See also Recovery Factor downlisting Status of Criterion 1 above. Full implementation of the nonnative fish stocking procedures and agreed upon content of a nonnative fish basinwide strategy are necessary mechanisms to aid in the protection of habitat. Recognition of the problem is exemplified by Utah in instituting a "must kill" policy on smallmouth bass and burbot (Lota lota) that enlists the help of anglers to remove them if caught in the Green River. In addition, Wyoming increased the penalty for "stocking fish without consent to" $10,000 and the loss of fishing and hunting privileges for life. Not all mechanisms for habitat protection have been explored, for instance, channel and flow manipulations.*

Criterion 14. Elements of conservation plans are identified that are necessary to provide for the long-term management and protection of bonytail populations.

Status of Criterion 14. Criterion 14 has not been met. *Conservation plans and the necessary elements have not been developed.*

Factor E — Other natural or manmade factors for which protection has been provided. The present levels of hybridization among *Gila* species is not considered a threat to the species, but this factor will be re-evaluated at downlisting because there will be enough bonytail and other *Gila* in the system to determine impacts. Any necessary actions to reduce deleterious levels of hybridization will be implemented before and after delisting.

Many potential contaminants (e.g., petroleum products, radionuclides, selenium, pesticides, and heavy metals such as mercury) enter into the Colorado River Basin from a variety of sources, but their role in affecting populations is not generally well understood. Potential spills of petroleum products threaten wild populations of bonytail. All States have hazardous materials spills emergency response plans that provide a quick cleanup response to accidental spills.

Another cause of degraded water quality is the Atlas Mills tailings pile located on the north bank of the Colorado River near Moab, Utah. There are significant threats to endangered fish posed by the Atlas Mills tailings pile: toxic discharges of pollutants, particularly ammonia, and the risk of catastrophic pile failure.

Criterion 15. Risk of hybridization to bonytail populations is evaluated and, if necessary, actions identified to minimize the risk.

Status of Criterion 15. Criterion 15 has not been met. *The risk of hybridization with other Gila spp. and bonytail has not been evaluated. Populations of wild reproducing bonytail need to be established before this determination can be made.*

Criterion 16. State and Federal hazardous materials spills emergency response plans are reviewed and modified to ensure adequate protection for bonytail populations from hazardous materials spills.

Status of Criterion 16. Criterion 16 has not been met. *The hazardous-materials spills emergency-response plans have not been reviewed or modified.*

Criterion 17. Locations of all petroleum-product pipelines within the 100-year floodplain of critical habitat identified and the need for emergency shut-off valves is assessed.

Status of Criterion 17. Criterion 17 has been partially met. *Although some progress has been made in locating all petroleum-product pipelines, the determination of emergency shut-off valves has not been fully assessed. The Service now requires (via Section 7 consultation) that new pipelines crossing the rivers are equipped with emergency shut-off valves.*

Criterion 18. Actions are identified for remediation of groundwater contamination at the Atlas Mills tailings pile located near Moab, Utah.

Status of Criterion 18. Criterion 18 has been met. *Under the Moab Uranium Mill Tailings Remedial Action Project Site Record of Decision (70 FR 55358), the action identified for remediation of groundwater contamination (principally ammonia) at the Atlas Mills tailings pile located near Moab, Utah, was to move the tailings pile to Crescent Junction, Utah. The pile is currently in the process of being moved and ground-water remediation (a very long-term commitment) is underway.*

LOWER BASIN RECOVERY UNIT

Factor A — Adequate habitat and range for recovered populations is provided. Streamflow regulation and associated habitat modification are identified as primary threats to bonytail. The decline of the species throughout the basin is attributed largely to extensive habitat loss, modification, fragmentation, and blocked fish passage associated with dam construction and operations. Bonytail were once abundant through most of the Colorado River Basin and a major cause of decline has been loss of a contiguous complement of habitats used by the various life history phases. Maintenance of streamflow is important to the ecological integrity of large western rivers.

Criterion 1. Flow regimes necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries are identified, implemented, evaluated, and revised, such that:

a) Adequate spawning habitat and appropriate spawning cues (e.g., flow patterns and water temperatures) are available to maintain self-sustaining populations.

b) Adequate nursery habitat is available to maintain self-sustaining populations.

c) Adequate juvenile and adult habitats (e.g., cover, resting, and feeding areas) are available to maintain self-sustaining populations.

Status of Criterion 1. Criterion 1 has not been met. *Flows on the lower Colorado River are determined through dam releases in accordance with agreements and interstate compacts that do not consider the habitat needs of bonytail. The ability of current and future river flow management to provide the needed habitat features without changes in flows will require additional research and monitoring.*

Criterion 2. Measures are identified to minimize entrainment of subadult and adult bonytail at problematic diversion and/or out-take structures.

Status of Criterion 2. Criterion 2 has not been met. *Locations where entrainment could occur on the lower Colorado River were identified in the LCRMSCP and a portion of the stocking of bonytail into the river is intended to offset any losses from entrainment. However, measures to minimize such entrainment of subadult or adult bonytail from problematic diversion or take out structures have not been identified.*

Criterion 3. Habitats are identified that are necessary for the establishment and maintenance of bonytail populations in the mainstem and/or tributaries.

Status of Criterion 3. Criterion 3 has been partially met. *Riverside sites have been identified and opportunities are being assessed (Service 2005; LCRMSCP 2011). Cooperative agreements are in place to provide development of riverside sites, including long-term monitoring and support.*

Factor B — Protection from overutilization for commercial, recreational, scientific, or educational purposes. Overutilization of bonytail for commercial, recreational, scientific, or educational purposes is not currently considered a threat to the species. Bonytail have no commercial or recreational value and are not sought by commercial fishermen or anglers; however, on Lake Havasu bonytail are occasionally captured by anglers near the mouth of the Bill Williams River (Service data). Signs are posted at fishing access points around the lake with photographs of bonytail and instructions to release any captured alive and report the capture to the Service or State game and fish agency. Collection of bonytail for scientific or educational purposes is regulated by the Service under the ESA.

Criterion 4. Overutilization of bonytail for commercial, recreational, scientific or educational purposes re-evaluated and, if necessary, actions identified to ensure adequate protection.

Status of Criterion 4. Criterion 4 has been met. *No commercial or deliberate recreational activities exist. Educational activities are minimal and do not threaten bonytail. Scientifically, mortality was independent of handling; however, bonytail recaptured in hoopnets multiple times had significantly lower growth than those not handled (Paukert et al. 2005). Trammel net captures at temperatures 20°C or greater result in delayed mortality of bonytail (Hunt 2008). Researchers recommend that sampling with trammel nets should stop when water temperatures are 20°C or greater. In the Lower Basin, individual fish are taken occasionally by fishermen in Lake Havasu, but not considered a threat.*

Factor C — Adequate protection from diseases and predation. Diseases and parasites are not considered to be significant by themselves in the decline of the bonytail.

A large number of nonnative fishes are found in historic and currently occupied habitat of bonytail. Nonnative species are a major cause for lack of recruitment in the native fishes, particularly bonytail. Control of the release and escapement of nonnative fishes into the main river, floodplain, and tributaries also is a necessary management action to stop the introduction of new fish species into occupied habitats and to thwart periodic escapement of highly predaceous nonnatives from riverside features.

Criterion 5. Effects of diseases and parasites on bonytail populations are re-evaluated and, if necessary, actions identified to ensure adequate protection.

Status of Criterion 5. Criterion 5 has not been met. *The effects of diseases and parasites on bonytail populations have not been re-evaluated. The parasitic crustacean anchor worm (Lernaea sp.) and fungal infections may affect populations being re-established because the individuals come from clean facilities and must develop an immunity once released to the wild. In the Upper Basin, Bestgen et al. (2008) noted many stocked bonytail at large less than 4 months had Lernaea or fungal infections.*

Criterion 6. Procedures are developed, implemented, evaluated, and revised for stocking and to minimize escapement of nonnative fish species into the mainstem, floodplain, and tributaries to minimize negative interactions between nonnative fishes and bonytail.

Status of Criterion 6. Criterion 6 has not been met. *No procedures have been developed for stocking or minimizing the escapement of nonnative fish species in the Lower Colorado River Basin.*

Criterion 7. Control programs for problematic nonnative fishes in the mainstem, floodplain, and tributaries are developed and implemented to identify levels of control that will minimize negative interactions between nonnative fishes and bonytail.

Status of Criterion 7. Criterion 7 has not been met. *No control programs have been developed for problematic nonnative fish to minimize negative interactions between nonnative fishes and bonytail in the Lower Colorado River Basin.*

Factor D — Adequate existing regulatory mechanisms. Implementation of regulatory mechanisms is necessary for recovery of the bonytail and to ensure long-term conservation of the species. After removal from the list of threatened and endangered species and from protection by the ESA, the bonytail and its habitat will continue to receive consideration and some protection through the following Federal laws and related State statutes: National Environmental Policy Act; Clean Water Act; Organic Act; and Fish and Wildlife Coordination Act.

The need for conservation plans and agreements is identified in these revised recovery goals to provide reasonable assurances that recovered bonytail populations will be maintained.

Criterion 8. Mechanisms are determined for legal protection of adequate habitat.

Status of Criterion 8. Criterion 8 has been partially met. *The LCRMSCP has focused on securing partnerships with resource agencies to ensure adequate land and water resources were available to create habitat and provide for its long-term maintenance. Eleven conservation areas are now in the program or being considered for inclusion. These conservation areas are distributed over 276 river miles from Laughlin, Nevada, to the boundary with Mexico and include over 200 acres of marsh and 15 acres of backwater dedicated to native fish. Mechanisms to adequately control nonnative species need to be more fully explored.*

Criterion 9. Elements of conservation plans are identified that are necessary to provide for the long-term management and protection of bonytail populations.

Status of Criterion 9. Criterion 9 has been met. *The Lower Colorado River Management Plan (Service 2005) provides for the long-term management and protection of bonytail populations in the lower Colorado River. This signatory document among the Service and the States of Arizona, California, and Nevada for the management of big-river fish in the Lower Colorado River Basin provides management strategies for genetic and habitat protection, along with population management.*

Factor E — Other natural or manmade factors for which protection has been provided. Intergrades among the Colorado River *Gila* have been reported by several investigators. The present levels of hybridization among *Gila* species are not considered a threat to the species, but this factor will be re-evaluated at downlisting and any necessary actions to reduce deleterious levels of hybridization will be implemented before and after delisting.

Criterion 10. Risk of hybridization to bonytail populations evaluated and, if necessary, actions identified to minimize the risk.

Status of Criterion 10. Criterion 10 has not been met. *The risk of hybridization between other Gila species and bonytail has not been evaluated, but is likely very low because other Gila species are not distributed in areas where bonytail is being recovered in the lower basin.*

2.3 Synthesis

Recovery is based on reduction or removal of threats and improvement of the demographic status of a species. Recovery is achieved when management actions and associated tasks have been implemented and/or completed to allow genetically and demographically viable, self-sustaining populations to thrive under minimal ongoing management and investment of resources. Achievement of recovery does not mandate returning a species to all or a significant portion of its historic range, nor does it mandate establishing populations in all possible habitats, or everywhere the species can be established or re-established.

Bonytail evolved in warm-water reaches of large rivers of the Colorado River Basin from Mexico to Wyoming. At the time of listing, habitat losses were documented, but the threats to bonytail were poorly understood, and distribution and abundance of the species were not well known. The decline of the species was probably due to a combination of threats, including direct loss of habitat, changes in flow and temperature, and blockage of migration routes by the construction of large reservoirs. In addition, interaction with nonnative fish may have decimated bonytail in many areas, including waters not affected by dams.

Recovery of bonytail is considered basinwide, with the basin being separated into an upper basin and lower basin recovery unit. The analysis above of the demographic criteria has shown that 1 of 10 has been met, none have been partially met, and 9 have not been met (TABLE 3). Thus, the species has not yet achieved the demographic recovery goals we identified as likely to be indicative of healthy, viable, and sustainable population levels. From the analysis above of the recovery factor criteria, 6 of the 28 downlisting recovery factor criteria have been met; 11 have been partially met, and 11 have not been met. Thus, the majority of the most meaningful threats remain unresolved including providing adequate habitat, protection from predation and protection from degraded water quality. These factors continue to act upon the species both inhibiting the ability of the species to achieve its demographic goals and, thus, precluding achievement of recovery and delisting. Although the category "has been partially met" is identified, this is only to reflect that some progress is being made on that particular criterion. Since the majority of demographic (9 out of 10) and recovery factor downlisting criteria (22 out of 28) have not been completely met, threats remain and populations remain unsustainably low and the species still qualifies for the status of endangered ("any species which is in danger of extinction throughout all or a significant portion of its range-" Section 3.6 of the ESA); no change in status of bonytail is recommended. The definition of endangered applies here until the demographic criteria are met and the threats minimized or removed.

TABLE 3. Summary of the downlisting demographic and recovery factor criteria in the Colorado River Basin and a determination if the criteria have been met, partially met, or not met for analyzing whether bonytail can be downlisted.

CRITERIA FOR DOWNLISTING	Has Been Met	Has Been Partially Met	Has Not Been Met
Demographic			
Upper Colorado River Subbasin			1a, 1b, 1c, 2a, 2b, 2c
Lower Colorado River Subbasin	1		2a, 2b, 2c
Upper Basin Recovery Factors			
Recovery Factor A	2, 3	1, 4, 5	6
Recovery Factor B	7		
Recovery Factor C		9, 10, 11, 12	8
Recovery Factor D		13	14
Recovery Factor E	18	17	15, 16
Lower Basin Recovery Factors			
Recovery Factor A		3	1, 2
Recovery Factor B	4		
Recovery Factor C			5, 6, 7
Recovery Factor D	9	8	
Recovery Factor E			10

3.0 RESULTS

3.1 Recommended Classification

_X_ No change is needed; remain as endangered.

3.2 New Recovery Priority Number:

Imminent threats of habitat modification, predation by nonnative fish, and potential spills or leaching of environmental contaminants still remain high for bonytail. Bonytail is taxonomically classified as a species and represents a distinctive gene pool. Bonytail has a low recovery potential because its biological and ecological limiting factors along with threats are poorly understood. In addition, intensive management is required with uncertain probability of success. Under the 1983 "Endangered and Threatened Species Listing and Recovery Priority Guidance" (45 FR 43098) these three qualities result in a RPN of "5." Also, bonytail, as with the other three endangered fish of the Colorado River basin, are designated with a "C" after their RPN to indicate they are in conflict with development projects, such as water diversions or dam construction, and affect economic activities within the basin. Hence, no change in the RPN of "5C" is recommended.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The UCREFRP and the LCRMSCP continue to work on meeting the recovery criteria to minimize or remove threats to the bonytail in their respective areas. These programs develop annual work plans through adaptive management (Recovery Implementation Program Recovery Action Plan, and Work Plan and Budget, respectively) to minimize and remove threats to the bonytail and thus, achieve the recovery criteria. Improving augmentation programs to re-establish populations and meeting recovery criteria, the demographics of the species should improve.

We recommend revising the Service's 2002 bonytail recovery goals to incorporate information on population dynamics and other relevant information gathered since 2002. More specifically, the as-written Recovery Goal requirement that these populations always display positive recruitment (i.e., recruitment that is greater than adult mortality) contradicts the best available information that indicates these re-established populations likely will experience fluctuations.

Uncertainty surrounding the effects of climate change to the bonytail should be considered for each of the threats as those impacts are realized. For example, the potential for alteration of flows in the basin as a result of climate change should at least be mentioned in the recovery goals. Climate change could have large impacts on the basin's aquatic ecosystem, resulting in (but not limited to):

- Change in the timing of peak flows from an earlier snowmelt;
- Change in the size of peak flows because of altered snowpacks; and
- Higher water temperatures from increased air temperature.

Not only could climate change affect the ecology of the species because of the factors listed above, but it also would greatly affect the management of the programs through changes in politics and economics, such as:

- Greater evaporation losses in the larger reservoirs may reduce flexibility of operations; and
- Drier conditions in the basin may cause irrigators to call on their water rights more often or request more water rights.

Therefore, we recommend that the recovery programs collaborate with their respective Landscape Conservation Cooperatives as means to address the challenges associated with climate change on the appropriate scale.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Bonytail*

Current Classification: Endangered rangewide

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Review Conducted By: Upper Colorado River Endangered Fish Recovery Program Office

FIELD OFFICE APPROVAL:

Upper Colorado River Endangered Fish Recovery Program Office

Approve _____ Date 8/7/12
Thomas Chart, Program Director

LEAD REGIONAL OFFICE APPROVAL:

Mountain-Prairie Region (Region 6)

Approve _____ Date 8/17/12
Michael Thabault, ARD-Ecological Services

COOPERATING REGIONAL OFFICES:

Southwest Region (Region 2)

✓ Concur ____ Do Not Concur

Signature _____ Date 8/24/12
Acting for Michelle Shaughnessy, ARD-Ecological Services

Pacific Southwest Region (Region 8)

____ Concur ____ Do Not Concur

Signature _____ Date 8/30/12
Michael Fris, ARD-Ecological Services

EXHIBIT 36

RECOVERY PLAN
FOR
COLORADO PIKEMINNOW (*Ptychocheilus lucius*)



Photo by J. Ferreira

U.S. Fish and Wildlife Service
Mountain-Prairie Region
Denver, Colorado

September 2023 – Final Recovery Plan

Final Approved_____ **Date**_____
Deputy Regional Director, U.S. Fish and Wildlife Service

Disclaimer

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.), requires the development of recovery plans for listed species, unless such a plan would not promote the conservation of a particular species. Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. The U.S. Fish and Wildlife Service (Service) publishes the plans, which are often prepared with the assistance of recovery teams, contractors, State agencies and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions. Please check for updates or revisions at the website below before using.

Recommended Citation:

U.S. Fish and Wildlife Service. 2023. Recovery plan for Colorado pikeminnow (*Ptychocheilus lucius*). September 2023. U.S. Fish and Wildlife Service, Mountain-Prairie Region, Denver, Colorado. 28 pp.

This recovery plan and its associated documents can be downloaded from the U.S. Fish and Wildlife Service's website: *https://ecos.fws.gov/ecp/species/3531*.

Technical terms are underlined in their first use and defined in the Glossary at the end of this document.

Prepared by M. Tildon Jones, U.S. Fish and Wildlife Service, Upper Colorado River Endangered Fish Recovery Program, Lakewood, Colorado.

Acknowledgments:

The U.S. Fish and Wildlife Service would like to thank the following individuals and their respective organizations for their dedicated efforts to the recovery of the Colorado pikeminnow. Without their assistance, the development of this recovery plan for this species would not have been possible:

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I. Introduction

Colorado pikeminnow (*Ptychocheilus lucius*) is a fish in the minnow family (Cyprinidae) that once inhabited warmwater reaches throughout the Colorado River Basin. Colorado pikeminnow was included in the original 1967 List of Endangered Species (32 FR 4001; March 11, 1967) and listed in 1973 as endangered under the Endangered Species Act, as amended (16 U.S.C. 1531 *et seq*; hereafter, Act). In 1994, the U.S. Fish and Wildlife Service (Service) designated critical habitat for Colorado pikeminnow in the Green, upper Colorado, and San Juan subbasins of the upper Colorado River basin (59 FR 13374; March 21, 1994). The Service approved a recovery plan for Colorado pikeminnow in 1991 (Service 1991, entire), which was amended and supplemented with Recovery Goals in 2002 (Service 2002, entire). The most recent 5-year status review (Service 2020, entire) recommended revising the recovery plan based on new information gathered from extensive research completed over the last two decades and an increase in some threats to the species since 2002. On November 28, 2022, we noticed the availability of the draft recovery plan for public review and comment. Appendix A provides a summary of the comments received and our responses, and we have updated the recovery plan accordingly.

The Service conducted a species status assessment (SSA) for the Colorado pikeminnow and documented our analysis in an SSA report (Service 2022, entire), which is an in-depth, scientific review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain populations over time. In our SSA, we identified individual, population, and species requirements, or needs, and the factors affecting the species' survival. We then evaluated the species' current condition to assess the species' current and future viability in terms of its resiliency, redundancy, and representation (the three Rs). Resiliency is the ability for populations to sustain in the face of stochastic events, or for populations to recover from years with low reproduction or reduced survival, and is associated with population size, growth rate, and the quality and quantity of habitats. Redundancy is the ability for the species to withstand catastrophic events, for which adaptation is unlikely, and is associated with the number and distribution of populations. Representation is the ability of a species to adapt to changes in the environment and is associated with its diversity, whether ecological, genetic, behavioral, or morphological.

This streamlined recovery plan for Colorado pikeminnow is derived from the SSA (Service 2022, entire) and focuses primarily on the elements required under section 4(f)(1)(B) of the Act:

(i) A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;

(ii) Objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and

(iii) Estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In cooperation with our partners, the Service also prepared a Recovery Implementation Strategy (RIS), which serves as an operational plan for completing the higher-level recovery actions presented in this recovery plan by achieving specific tasks, or activities. The RIS is a separate document from this recovery plan and can be modified as needed if monitoring reveals that expected results are not being achieved, therefore maximizing flexibility of recovery implementation. The SSA can also be updated as needed to incorporate the latest scientific information. To summarize, there are three documents under our recovery planning and implementation (RPI) process: (1) the SSA, which provides the foundational scientific information to guide recovery planning; (2) the recovery plan (this document), which provides the recovery vision, objective and measurable recovery criteria, site-specific management actions, and estimates of time and cost; and finally (3) the RIS, which is the operational plan of detailed activities associated with the actions identified in the recovery plan that are needed for recovery.

Overview of Status and Life History

The following is a brief overview of the biology, natural history, and current condition of Colorado pikeminnow, per the SSA report (Service 2022, entire). Please refer to the SSA report (Service 2022, entire) for additional discussion, full analysis, and complete literature citations.

Summary of Taxonomy, Life History and Ecology

Colorado pikeminnow is a large, long-lived fish and the largest member of the taxonomic family Cyprinidae native to North America. It is endemic to warmwater reaches of large rivers in the Colorado River basin. Prior to the introduction of nonnative, predatory fish species, Colorado pikeminnow was the apex predator in these reaches and adults are mostly piscivorous. Colorado pikeminnow can grow to a large size, historically greater than 5 feet (1.5 meters) in length and can live over 50 years in the wild. Colorado pikeminnow make long distance migrations (409 miles (mi) [658 kilometers (km)] round trip) to spawn and return to their home range, where they inhabit deep runs, pools, and eddies. Colorado pikeminnow eggs hatch in cobble spawning bars as spring high flows decline, and larvae subsequently emerge and are carried long distances by river flows to low velocity nursery habitats downstream. In these reaches, larvae and juveniles seek low to zero velocity backwaters that provide warm temperatures for growth and abundant macroinvertebrates and small fish prey. Individual Colorado pikeminnow become sexually mature between 7 and 10 years of age and may spawn each year during their lifetime.

Historically, Colorado pikeminnow occurred throughout the Colorado River basin, including the Green, Colorado, and San Juan River subbasins of Wyoming, Colorado, Utah, and New Mexico; downstream through the Colorado River mainstem in Arizona, Nevada, California, and Mexico; and the Gila River subbasin in Arizona and New Mexico (Figure 1). In the lower Colorado River basin (LCRB or 'lower basin') downstream of Glen Canyon Dam, the construction of dams and water projects diverted river flows, fragmented river reaches, reduced peak flows, dewatered some reaches, and channelized the river starting in the early 20th century. As a result of extensive water development, modified hydrology, and reduced habitats, Colorado pikeminnow was extirpated from the LCRB by the 1970s. In the upper Colorado River basin (UCRB or 'upper basin'), including Lake Powell and its tributaries, the construction of large

dams and diversions was more dispersed, leaving longer reaches of river available in downstream areas. The remaining UCRB reaches were sufficiently intact to provide habitats that supported Colorado pikeminnow populations in the wild, albeit across a reduced range and in decreased numbers. Dams converted sections of rivers to coldwater tailraces, impounded extensive reservoirs with unsuitable habitat for riverine species including Colorado pikeminnow, altered hydrology through reduced spring peaks, and presented barriers to migration. Nonnative sport fishes were also introduced into reservoirs and riverine habitats throughout the entire Colorado River basin, and these nonnative fish compete with and prey upon Colorado pikeminnow. The range of Colorado pikeminnow in the UCRB contracted and populations declined in the Green and upper Colorado River subbasins; the species was functionally extirpated from the San Juan River subbasin in the late 1990s. Those same factors also resulted in earlier extirpation of Colorado pikeminnow from the LCRB. Designated critical habitat in the UCRB is estimated to represent around 29 percent of historical Colorado pikeminnow range (59 FR 13374; March 21, 1994).

Other habitat factors also influence Colorado pikeminnow life history. Colorado pikeminnow inhabit river reaches that historically experienced extremes in both flow and temperature on an annual basis, in addition to high turbidity from sediment inputs as a result of spring snow melt or flash floods. Both adult and nursery habitats, as well as spawning bars, are formed and maintained by high, snowmelt-driven spring flows that redistribute sediment, clean cobble substrates, and maintain channel complexity to provide a diversity of habitats. Base flows the rest of the year maintain these habitats by providing sufficient water depth for movement between reaches. Summer base flows also transport larval Colorado pikeminnow to nursery habitats and determine the quantity and quality of those nursery backwaters. In addition to flows sufficient to create and maintain habitats, Colorado pikeminnow requires relatively warm water temperatures to initiate spawning (greater than 16–18°Celsius [C; 61–64°Fahrenheit (F)]), incubate eggs (18–26°C [64–79°F]), and support larval and juvenile growth (22–30°C [72–86°F]). Because Colorado pikeminnow often migrate to specific spawning sites with clean cobble bars, and adult, juvenile, and larval life stages require different habitat types, Colorado pikeminnow require a variety of connected habitats arranged in a particular longitudinal fashion. In addition, adult Colorado pikeminnow occupy home ranges in reaches of river that provide a forage base comprised of suitable abundance and species of prey fishes. As a result, the extent of connected riverine habitats contributes to basin carrying capacity for Colorado pikeminnow populations.

Summary of Threats

Changes in the flow regime as a result of water development throughout the Colorado River basin led to initial declines in Colorado pikeminnow populations. In some cases, this development created barriers to movement in the form of dams and diversions, which have fragmented river reaches and limited access to historical habitats. Diversions can also entrain fish into water delivery systems and lead to direct mortality. Large dams can alter water temperatures through hypolimnetic releases, creating conditions too cold for Colorado pikeminnow growth and reproduction. Water storage and flow management often reduce spring peaks necessary to create and maintain spawning and nursery habitats needed by Colorado pikeminnow, and also reduce base flows, which can limit Colorado pikeminnow range and

reduce habitat availability. Predation and competition from invasive, nonnative fishes reduce survival and recruitment of Colorado pikeminnow in all life stages. Contaminants that impact water quality can reduce reproduction and survival of individuals or lead to population reductions in the case of large, toxic spills. Lastly, climate change and extended drought reduce streamflow in many river reaches, which strains efforts to manage flows to benefit Colorado pikeminnow (Service 2022, pp. 28–44).

Summary of Current Resiliency

The SSA report (Service 2022, entire) evaluated six "analysis units" throughout the Colorado River Basin based on geographic subbasins delineated by dams and reservoirs: Green River, upper Colorado River, San Juan River, Colorado River in Grand Canyon, Gila River, and lower Colorado River mainstem (Figure 1). Colorado pikeminnow has been extirpated from the three LCRB units (Grand Canyon, Gila River, and lower Colorado River). The three UCRB units are delineated by subbasins and treated as populations. Demographic processes occur independently within each UCRB river subbasin, although individuals do move between the Green and upper Colorado rivers. In these three, extant UCRB subbasins (Green River, Upper Colorado River, and San Juan River), each population currently has a low overall condition for demographic factors (Service 2022, p. 102). In the Green and upper Colorado River subbasins, low adult abundances and declines in adult numbers over the last 15–20 years influenced the low condition of the demographic factors. These population declines were the result of low production of age-0 fish and reduced recruitment. For the San Juan River subbasin, the low overall condition was a result of low reproduction, low adult abundances, and a lack of wild recruitment, despite the adult population increasing due to stocking (Service 2022, pp. 87–100). Currently, populations in all three subbasins demonstrate low resiliency (Figure 1) (Service 2022, pp. 86–102).

Summary of Current Redundancy

Colorado pikeminnow currently inhabits three river subbasins in the UCRB: the Green, upper Colorado, and San Juan (Figure 1). Although individuals move between the Green and upper Colorado Rivers, the San Juan River basin is isolated from the other two subbasins by Lake Powell and a waterfall at its downstream inflow to the reservoir. The population in the Green River subbasin is the largest of the three and inhabits the longest extent of riverine habitat (794 mi [1,278 km]) (Service 2022, pp. 106–107). The upper Colorado River subbasin has supported the second largest population distributed over 296 mi (476 km) of river, and the San Juan River subbasin's population has been increasing through stocking and occupies 216 mi (347 km). Colorado pikeminnow had been stocked into the Salt and Verde rivers in the Gila River subbasin, but survival has been very low. Arizona Game and Fish Department ceased stocking Colorado pikeminnow in 2018, and there are currently no plans to resume (Service 2022, p. 100). Therefore, current redundancy is described by the three extant populations as they are distributed across the river basins in the Green, San Juan, and upper Colorado River subbasins (Figure 1) (Service 2022, p. 122). These three populations occur in over 1,300 mi (2,092 km) of river across the UCRB in several mainstem and tributary reaches.

Summary of Current Representation

Colorado pikeminnow is limited to three populations in the Upper Colorado River Basin: the Green, upper Colorado, and San Juan River subbasins (Figure 1). Populations in the LCRB were extirpated by the 1970s, and it is not clear to what extent Colorado pikeminnow in the lower basin may have been unique from extant populations in the upper basin. The Green and upper Colorado River populations are remnant wild populations that represent the genetic and behavioral diversity remaining for wild populations. Genetic analyses have not found evidence of differentiation between these two wild populations, but little research has been conducted using modern techniques. Colorado pikeminnow in the San Juan River subbasin are mainly derived from broodstock developed from fish collected in the Green and Colorado Rivers. As a result, the San Juan River population of Colorado pikeminnow reflects the genetic composition of fish stocked in that system. Although the current distribution of Colorado pikeminnow represents the remnant wild populations in the UCRB, the most recent genetic studies have not found evidence of low diversity or deviation from expected allele frequencies (Service 2022, pp. 123–125). In addition, individuals in these three populations use and make extensive movements between a variety of mainstem and tributary habitats throughout the three subbasins. As a result, maintaining the existing genetic and behavioral diversity found in these populations should allow the species to adapt to changing conditions over time.

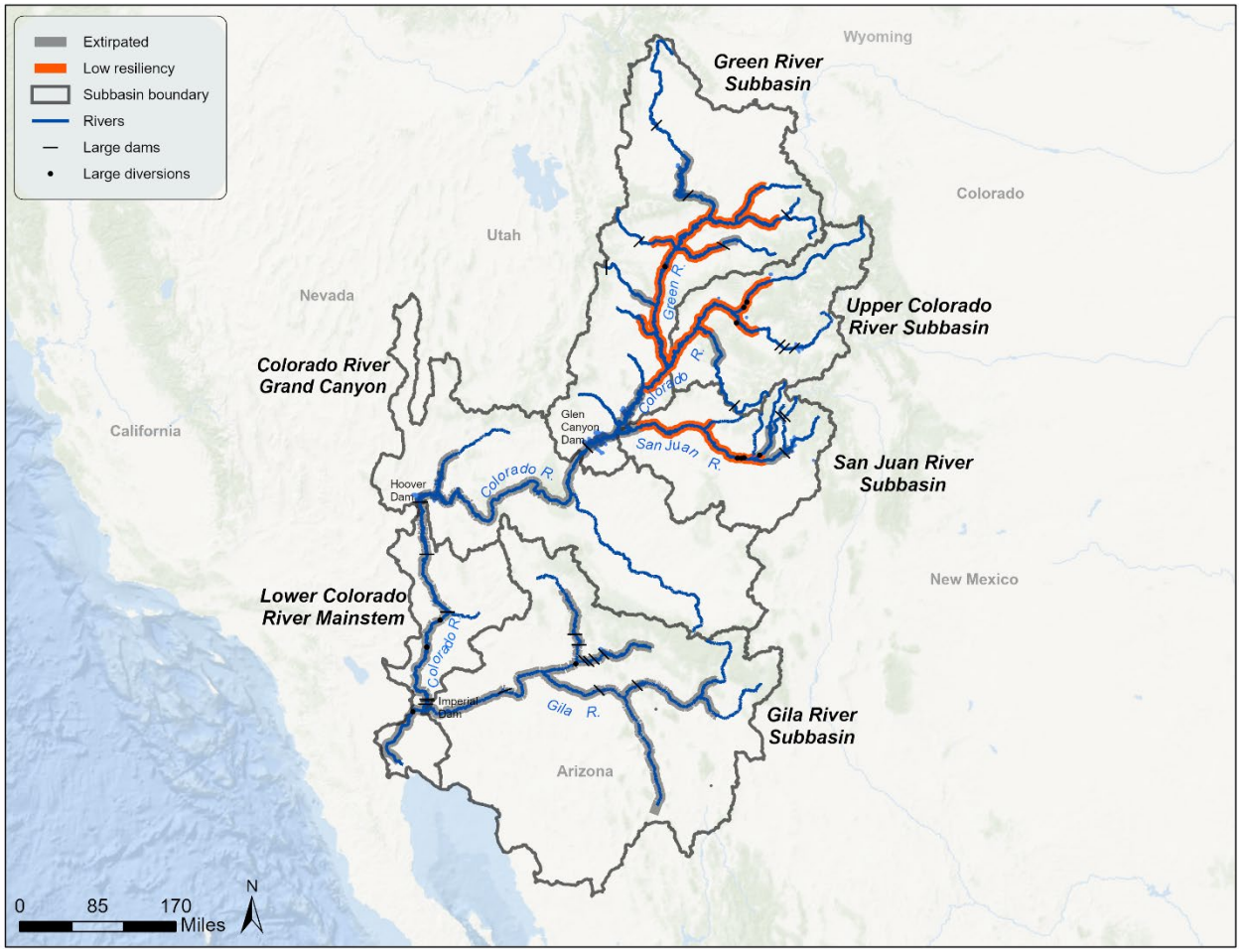


Figure 1. Current conditions of Colorado pikeminnow populations in each subbasin.

Recovery Vision

The recovery vision is the conservation and survival of Colorado pikeminnow. Recovery for Colorado pikeminnow will be signified by at least three populations: two with high resiliency distributed in the Green and upper Colorado River subbasins and one population with at least moderate resiliency in the San Juan River subbasin. These conditions would preserve the current genetic, behavioral, and ecological diversity across suitable habitats within a portion of the species' historical range.

Recovery Strategy

The recovery strategy describes the path needed to achieve the recovery vision. The Service measures species viability in terms of resiliency, redundancy, and representation, as described in the SSA report (Service 2022, entire). Through the recovery vision, recovery criteria, and recovery actions outlined in this recovery plan, we attempt to conserve representation and improve resiliency and redundancy of Colorado pikeminnow.

We consider Colorado pikeminnow populations resilient when they are sufficiently large to endure stochastic environmental change. Achieving such population sizes and vital rates is reliant on the quantity, quality, and distribution of riverine habitats supported by flow management. Due to the long lifespan of individuals, Colorado pikeminnow populations also require demographic processes to be sufficient to replace adults over extended timeframes. Specifically, large populations of Colorado pikeminnow alone may not adequately represent resiliency in the absence of adequate reproduction and recruitment, since adults may live many years without new individuals recruiting to replace them. As a result, the recovery criteria listed below are designed to evaluate both current resiliency for adult populations in each subbasin, as well as the likelihood for populations to persist into the future based on trends in reproduction and recruitment.

Currently, all three subbasins have low resiliency (Service 2022, p. 102), so the recovery strategy for Colorado pikeminnow is to implement recovery actions and activities to improve the resiliency of populations in the Green and upper Colorado River subbasins from low resiliency to high resiliency, and from low resiliency to moderate resiliency in the San Juan River subbasin, as described in the SSA report (Service 2022, pp. 83–85). Once these populations' conditions are improved, additional recovery actions and the achievement of two threats-based criteria will ensure the species needs are met to maintain at least three populations with moderate to high resiliency. Four demographic recovery criteria and two threat-reduction recovery criteria are described below to objectively measure progress toward achieving the recovery vision.

The four demographic recovery criteria are described at a subbasin scale, recognizing all mainstem and tributary habitats contribute to recovery. Tributaries, in addition to mainstem reaches, will be important to achieve demographic criteria. Providing a variety of habitats and resources throughout each subbasin will be necessary to reach the degree of resiliency needed for recovery. As mentioned previously, the life history needs of Colorado pikeminnow individuals change as they grow from age-0 juveniles to mature adults. Tributaries can provide spawning, feeding, and home range resources needed to fulfill these life history requirements. Increasing the distribution of these resources in different locations can increase the likelihood that a needed

habitat feature is available when environmental conditions limit resources in another location. Finally, a larger network of quality habitats can support higher abundances by increasing the carrying capacity within a particular subbasin. It also reduces the chance that a catastrophic event (e.g. debris flow from wildfire burn scars) will affect the entire population, since individuals should be spread across a larger area or have access to suitable reaches.

Achieving recovery for Colorado pikeminnow will require stabilizing populations that have been declining and then increasing adult abundances in all three extant populations (Green River, Upper Colorado River, San Juan River). To support and improve adult abundance in these populations, flow management actions should continue or be improved to meet the species' needs, particularly for spawning and survival of juvenile fish. Recovery actions to provide and maintain access across Colorado pikeminnow current range will allow adults to access specific habitats needed to establish home ranges, forage, and spawn. The negative effects of nonnative fish to all life stages of Colorado pikeminnow need to be reduced to increase survival and recruitment, which will likely require developing new methods to deal with invasive fish species. Finally, a captive broodstock, or broodstocks, should be developed to conserve the genetic diversity of extant wild populations. This last action is intended to not only provide a genetic refuge should wild populations decline, but a broodstock can also be used to augment or restore populations where necessary.

As Colorado pikeminnow populations stabilize, the second suite of actions will assist in improving conditions, supporting increased adult abundances, and improving demographic processes. These include actions that maintain the forage base and habitats to support all life stages of Colorado pikeminnow, protecting water quality, expanding access to habitats necessary to achieve resilient populations, operating dams to provide suitable water temperatures, and reducing risks associated with resident nonnative species or those with the potential to be introduced. Second priority actions listed above further reduce threats to the species and improve conditions to support populations at resilient levels indicated in the recovery criteria.

The recovery vision addresses the needs of Colorado pikeminnow by identifying three subbasins with resilient populations that represent the species' existing genetic diversity. This vision also provides redundancy by maintaining, at a minimum, the three populations in the UCRB subbasins. The lack of specific recovery criteria for LCRB habitats does not minimize the importance of conservation actions or the pursuit of opportunities to establish populations in the LCRB. Rather, uncertainties around the potential for establishing Colorado pikeminnow and the demographic response in LRCB habitats preclude the ability to develop objective and measurable criteria for these areas. As conditions change, additional areas within the species' historical range should be evaluated for their recovery potential. For example, experts have identified potential habitat in Grand Canyon that may support Colorado pikeminnow (Service 2022, pp. 103–119; Dibble 2023, entire). Should habitat conditions and recovery potential improve, any Colorado pikeminnow in the LCRB or other reaches will be included in future SSAs and considered during 5-year status reviews. Although the LCRB is not described in the recovery vision and criteria, this does not negate the importance of conservation efforts that might occur there in the future. Populations established in the LCRB would benefit Colorado pikeminnow redundancy by adding to existing populations in the three UCRB subbasins, thereby improving the viability of the species.

II. Recovery Criteria

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the Act are no longer necessary and a species may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants (Lists). Downlisting is the reclassification of a species from an endangered species to a threatened species. The term "endangered species" means any species (species, subspecies, or Distinct Population Segment) that is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Revisions to the Lists, including delisting or downlisting a species, must reflect determinations made in accordance with sections 4(a)(1) and 4(b) of the Act. Section 4(a)(1) requires that the Secretary determine whether a species is an endangered species or threatened species (or not) because of threats to the species. Section 4(b) of the Act requires that the determination be made "solely on the basis of the best scientific and commercial data available." Thus, while recovery plans provide important guidance on methods of minimizing threats to listed species and measurable objectives against which to measure progress towards recovery, they are guidance and not regulatory documents. Recovery criteria help indicate when we would anticipate that an analysis of a species' status under section 4(a)(1) would result in a determination that the species is no longer an endangered species or a threatened species. A decision to revise the status of, or remove a species from the Lists, however, is ultimately based on an analysis of the best scientific and commercial data then available, regardless of whether that information differs from the recovery plan. When changing the status of a species, we first propose the action in the *Federal Register* to seek public comment, followed by a final decision announced in the *Federal Register*. The following recovery criteria are based on information compiled in the SSA report (Service 2022, entire), and other input provided by scientific experts.

The following recovery criteria, when met collectively, would indicate that Colorado pikeminnow may be considered for reclassification to threatened (downlisting) or may no longer need the protections of the Act (delisting):

Recovery Criteria 1 – Population Stability

> **Criterion 1 for Downlisting:** The overall trends in wild and stocked adult abundances are stable or increasing over a continuous 15-year period in the Green, upper Colorado, and San Juan River subbasins. Adult abundances will be measured using standardized estimation techniques.
>
> **Criterion 1 for Delisting:** The overall trends in wild adult abundances are stable or increasing over a continuous 15-year period in the Green, upper Colorado, and San Juan River subbasins. Adult abundances will be measured using standardized estimation techniques.

Justification for Criteria 1:

The long lifespan of Colorado pikeminnow necessitates evaluating populations' stability over timescales relevant to the species life history. To confidently capture potential changes in demographic processes, 15 years was selected for this criterion because it is based on the generation time of a female Colorado pikeminnow, who mature more slowly than males. Population stability, as measured by trends in adult abundances, may be supported by management through the addition of stocked fish into the population, which adds specificity when evaluating adult population sizes under Recovery Criteria 2, below. To meet delisting criteria, stable or increasing trends in adult populations would need to be the result of wild fish abundance patterns. This recognizes the need for populations to be self-sufficient to be considered resilient. Stocked fish that survive to adult size are included in the downlisting criterion since stabilizing or increasing population sizes would reduce the threat of immediate extinction. The 15-year time scale allows for short term fluctuations in demographic processes due to environmental variation inherent to the Colorado River basin but assesses trends over periods relevant to the species' life history. A continuous time period is specified to indicate that the overall trends should exhibit a stable or increasing pattern over a block of time, rather than 15 data points or interrupted series of years. A resilient population would be expected to recover from short-term declines and evaluating trends over a longer time interval should capture that population response.

A 15-year timeframe is based on generation time, using the formula in Valdez (2018, p. 37). This formula takes into consideration the age at reproductive maturity and annual adult survival. It represents the average time for a population to increase by a factor equal to the net reproductive rate and should therefore be a sufficient amount of time to detect changes in populations. In this case, we used 10 years as the age when females reproduce (Osmundson 2006, pp. 1569–1579) and an average annual survival of 0.8 for adults (Bestgen *et al.* 2005, p. 31; Osmundson and White 2009, p. 62; Bestgen *et al.* 2010, p. 35).

Recovery Criteria 2 – Population Size

Adult abundance thresholds are met over a consecutive 10-year period, as described in Table 1 for down- and de-listing.

Table 1. Adult Colorado pikeminnow abundances for each subbasin necessary to achieve Recovery Criteria 2 for both downlisting and delisting. (≥ is "greater than or equal to")

Population	Adult Abundance over a consecutive 10-year period	
	Recovery Criteria 2: Downlisting	**Recovery Criteria 2: Delisting**
Green River Subbasin	≥ 2,600 adults	≥ 3,100 adults
Upper Colorado River Subbasin	≥ 500 adults	≥ 760 adults
San Juan River Subbasin	≥ 250 adults	≥ 250 adults

Justification for Criteria 2

Adult Colorado pikeminnow abundances represent the reproductive potential for the species over long time scales, and because of the species' long lifespan, adult populations serve as indicators whether life history requirements are being met. In addition, long term monitoring for adult abundances in the Green and upper Colorado River subbasins provide data on population sizes in the recent past (1990s–2000s) when demographic processes appeared adequate to support resiliency. At a minimum, adult populations determine the species' ability to recover from stochastic events, since larger populations can better withstand unfavorable conditions. Finally, adults contribute to reproduction which replaces individuals lost from stochastic events. Stocked fish that survive to adult size may be included in achieving these criteria, and Criteria 3 and 4 (below) account for other life stages that contribute to the long-term viability of the species.

The timeframe of 10 consecutive years for adult abundance criteria is based on the age at which females reach sexual maturity (Osmundson 2006, pp. 1569–1579). This period of time would indicate adult abundances have been sustained long enough for young individuals to enter the adult population and contribute to reproductive success at a rate sufficient to replace adults as they die.

Due to differences in available habitat and extent of suitable river reaches, adult abundances are presented for each subbasin. For the Green and upper Colorado River subbasins, adult abundances for delisting criteria are based on population sizes observed in the 1990s and early 2000s, and adult numbers exceeded this criterion in those years when reproduction and recruitment appeared to be occurring at levels that supported resilient populations (Bestgen *et al.* 2007, entire; Osmundson and White 2017, entire; Bestgen *et al.* 2018, entire). San Juan River subbasin abundance criteria are based on estimated carrying capacity from bioenergetics modeling in currently available habitat (Miller and Lamarra 2006, entire; Miller 2014, pp. 58–59).

In the Green River subbasin, the downlisting criterion was developed from estimates of the minimum viable population (MVP) size (Service 2002, pp. 18–22). A minimum viable population identifies an abundance where a population should be viable or resilient and considers both environmental stochasticity and genetic diversity. Based on this concept, the MVP abundance of ≥2,600 adults was established for downlisting. In addition, since Colorado pikeminnow move between the upper Colorado and Green River populations, adult abundances in these two subbasins contribute to the viability of both populations. For the upper Colorado River subbasin, the downlisting criterion is based on observed adult abundances that have resulted from low recruitment rates in prior years. In this subbasin, the adult abundance from 1992 to 2010 averaged over 600 adults (Osmundson and White 2014, entire). When adult abundances were estimated to be less than 500 fish, it was believed to be the result of poor recruitment and years of low reproduction (Elverud *et al.* 2020, p. 30). Based on these data, the downlisting criterion of 500 adults for the upper Colorado River subbasin is based on adult abundance that would be expected to result from sufficient demographic processes to maintain the population, namely reproduction and recruitment. The downlisting criterion of 250 adults for the San Juan River subbasin is based on reaching the threshold for a "moderate" condition in adult abundance (Service 2022, p. 85) and reflects uncertainty in the size of population that

might be expected in that subbasin. The down- and de-listing criterion for the San Juan River subbasin is the same due to this uncertainty. The criterion represents an adult abundance below the carrying capacity, but much improved compared to recent estimates and is expected to reflect improvements in other demographic processes in the absence of stocking (Miller 2018, pp. 37–38). Finally, Colorado pikeminnow in the San Juan River subbasin are largely derived from broodstocks collected in the upper Colorado and Green River subbasins. The San Juan River population contributes to redundancy and maintains the species in a portion of its historical range.

Recovery Criteria 3 – Recruitment to Sexual Maturity

> **Criterion 3 for Downlisting:** Wild recruitment to sexual maturity equals or exceeds annual adult mortality over a continuous 10-year period in the Green, upper Colorado, and San Juan River basins.
>
> **Criterion 3 for Delisting:** Wild recruitment to sexual maturity equals or exceeds annual adult mortality over a continuous 15-year period in the Green, upper Colorado River, and San Juan River basins.

Justification for Criteria 3

These criteria for down and delisting recognize the importance of documenting recruitment to the adult life stage to confidently assess resiliency of populations. Again, because of Colorado pikeminnow's long lifespan, adult abundances alone may not reflect whether demographic processes are sufficient to maintain populations into the future. The 10- and 15-year time scales for this criterion reflect the age at which females reach maturity (see Recovery Criteria 2, above) and the generation time described for Recovery Criteria 1, above. Longer time scales also allow for short term fluctuations in demographic processes due to environmental variation but assess trends over periods relevant to the species' life history.

Recovery Criteria 4 – Reproductive Success

Mean density of wild age-0 juveniles collected in autumn standardized sampling meets thresholds described in Table 2 over a continuous 10-year period in the Green, upper Colorado, and San Juan River basins.

Table 2. Age-0 Colorado pikeminnow densities for each subbasin to meet recovery criterion 4.

River Subbasin	Downlisting and Delisting Criteria
Green River subbasin	≥5 age-0 per 100 m^2 habitat
Upper Colorado River subbasin	≥3.3 age-0 per 100 m^2 habitat
San Juan River subbasin	≥1.4 age-0 per 100 m^2 habitat

Justification for Criteria 4

Reproductive success, as measured by densities of age-0 fish collected in autumn, is likely a significant factor in recent declines or low abundance of Colorado pikeminnow populations. Despite displaying high adult abundances in the Green and upper Colorado River subbasins around the year 2000, Colorado pikeminnow populations in those two subbasins declined in response to low recruitment of age-0 fishes (Osmundson and White 2017, pp. 141–144; Bestgen *et al*. 2018, pp. 71–74). Low adult abundances and the need for augmentation in the San Juan River subbasin are believed to be the result of inadequate recruitment of fish produced in the wild (Miller 2018, pp. 15–16).

The specific criteria thresholds for each subbasin were derived from long-term monitoring studies or models developed to predict adult abundances. For the Green River subbasin, age-0 densities were derived from long-term mean densities in Bestgen and Hill (2016, entire) and analyses used in population models by Miller (2018, pp. 10–11). These densities represent the combined product of reproduction and recruitment in the first growing season after spawning and appear to be levels of reproduction needed to maintain or increase adult abundances over longer periods. Similar methods were used to derive long-term mean densities for Colorado pikeminnow in the upper Colorado River subbasin to inform PVA models (McAbee 2017, entire; Valdez *et al*. 2017, pp. 1–6; Miller 2018, pp. 13–14), and these densities help establish measurable indicators of reproduction and recruitment that should support adult abundances through time. For the San Juan River subbasin, age-0 densities were derived from models (Zeigler *et al*. 2021, pp. 15–19). These models used PVA projections from the Green River (Miller 2018, p. 10–12) to estimate the relationship between age-0 abundances and future adult population sizes. The models then predicted the density of age-0 fish captured based on their overall abundance in the river, availability of habitats, and sampling design. From these relationships, the models predicted that age-0 densities would need to be ≥1.4 age-0 fish per 100 m^2 to maintain or exceed an abundance of 250 adults.

Recovery Criterion 5 – Threats-based (Delisting)

Regulatory mechanisms or conservation plans are in place that include stakeholder commitments to management actions that support Colorado pikeminnow populations beyond delisting in the Colorado, Green, and San Juan subbasins. Commitments should include management actions such as controlling nonnative fishes, operating fish passages and entrainment reduction facilities,

and maintaining a genetic refuge. Plans or management actions should be revised and updated based on the best available science.

Justification for Criterion 5

Current actions to support recovery of Colorado pikeminnow are coordinated by the two recovery programs in the Upper Colorado River Basin and the San Juan River Basin. These programs were created to address the need for basin-wide recovery actions, thus meeting the requirements of the Act and associated regulatory documents. Certain management actions may need to continue in order to maintain conditions that support the species, even potentially following a delisting. Stakeholders will need to determine which entities will be responsible for management actions into the future through conservation agreements or other regulatory documents before delisting could occur. For example, without ongoing management, nonnative fishes will likely continue to pose a threat to Colorado pikeminnow at all life stages. Similarly, fish passages will be needed to maintain access to reaches of river that support adult abundance or habitats necessary to complete Colorado pikeminnow life history. Finally, it is recommended that a broodstock be maintained to serve as a genetic refuge in case of a catastrophic event. The demographic criteria indicate recovery could be considered if three populations meet the thresholds listed. With only three populations, and the potential for genetic differences to exist between the Green and upper Colorado River lineages, maintaining a genetic refuge will contribute to preserving diversity of the extant populations and provide redundancy in case of a catastrophic reduction in population size.

Recovery Criterion 6 – Threats-based (Delisting)

Flow management plans are in place that include stakeholder commitments to provide flows that support current populations of Colorado pikeminnow beyond delisting in the Colorado, Green, and San Juan basins. Commitments should include legally protecting flows in Colorado pikeminnow designated critical habitat in accordance with tribal, state, and federal laws. Commitments should also include providing flows that support the species in the Colorado, Green, Gunnison, San Juan, White[1], and Yampa Rivers and revising flow recommendations when appropriate and based on the best available science.

Justification for Criterion 6

As described above, peak and base flows are critical components of river habitats necessary for Colorado pikeminnow to complete its life cycle. In addition, the alteration of stream flows as a result of water development is specified as a factor contributing to the listing of Colorado pikeminnow (Service 2020, p. 17). The recovery programs and applicable Records of Decision (RODs) coordinate flow management throughout the current range of Colorado pikeminnow to support recovery. In the absence of recovery program coordination or regulatory compliance for the Act, it is unclear how flows will be provided to support Colorado pikeminnow populations. It will be necessary to provide certainty that adequate flows will be provided in the future to support Colorado pikeminnow populations, and that those flows will be conveyed through needed reaches.

[1] Current flow recommendations are interim.

III. Prioritized Recovery Actions

The following is a list of prioritized, site-specific management actions that when fully implemented are expected to result in recovery of Colorado pikeminnow. Priority 1 actions are based on currently available information that suggests those actions must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future. Priority 2 actions are those that must be taken to prevent a significant decline in population size or habitat quality or some other significant negative impact. The assignment of priorities does not imply that some recovery actions are of low importance but recognizes that lower priority items may be deferred while higher priority items are being implemented. Recovery actions are assigned a sequential identification number that does not reflect any additional rank or prioritization. Please refer to Table 3 for a clear association among recovery actions and the threats addressed by these actions. The RIS contains the specific tasks needed to implement these recovery actions.

In developing recovery actions for Colorado pikeminnow, several broad themes emerged that applied to most, if not all, of the recovery actions listed below. There are still uncertainties in the level of action and the species' response to actions, so research needs to be conducted to refine the needs of Colorado pikeminnow in each subbasin. The best available science from this research should be used to guide and implement recovery actions and management practices. In addition, recovery actions should be periodically evaluated and revised based on the response of Colorado pikeminnow populations. Finally, although demographic criteria have been developed for populations at a subbasin scale, we recognize the need to implement recovery actions in important tributaries as well as mainstem reaches. It is likely Colorado pikeminnow will need a variety of habitats available throughout each subbasin to achieve the degree of resiliency needed for recovery. These recovery actions will improve the ability of Colorado pikeminnow to withstand catastrophic events and long-term environmental change.

Priority 1 Actions

1. Manage river flows in all subbasins to include both inter- and intra-annual variability that approximates the natural hydrograph and supports Colorado pikeminnow life history. This action provides an ecologically based suite of flows throughout the year and between years. For example, spring peak flows should clean spawning substrates, maintain channel complexity, create nursery habitats, provide access to floodplains, and promote movements to spawning areas. Base flows should support fish movement, maintain food web productivity, transport larvae, and maintain nursery habitats.

2. Operate and maintain fish passage facilities in all subbasins to facilitate Colorado pikeminnow movement. This action provides habitat access across the species' current range that allows for use suitable to fulfill life history requirements.

3. Control nonnative fish populations that reduce Colorado pikeminnow abundance and survival, particularly in the Colorado and Green River subbasins. This action improves Colorado pikeminnow recruitment and survival by reducing predation and competition from problematic nonnative species. Successful implementation of this action will minimally involve determining the level of invasive species reductions needed to improve Colorado pikeminnow demographics, developing new strategies and methods,

and implementing additional or novel methods to suppress or eradicate nonnative fishes at a landscape scale.

4. Develop captive broodstock(s) from wild fish to maintain existing genetic diversity of populations in the Colorado and Green River subbasins. This action protects the extant genetic and life history lineages. Broodstock(s) should serve as a genetic refuge and provide offspring for augmentation programs where needed. If determined necessary to meet demographic recovery criteria, this action should include production, rearing, and stocking sufficient numbers of Colorado pikeminnow to meet stocking goals and augmentation plans.

Priority 2 Actions

5. Conserve, or improve, native fish communities to provide a forage base for all life stages of Colorado pikeminnow in all subbasins. This action supports growth and survival of Colorado pikeminnow. Supporting native fish communities may include controlling nonnative fish to reduce impacts to native fish species and augmenting or reintroducing native fish species where necessary, in addition to implementing flow management described for Colorado pikeminnow.

6. Create and maintain habitats for Colorado pikeminnow using mechanical restoration methods or flow management actions in all subbasins. This action provides necessary habitats through a variety of mechanisms, including if climate change causes natural hydrologic conditions to become insufficient to perform habitat maintenance functions. Flow management activities under this action might differ from those intended to directly benefit Colorado pikeminnow populations, such as flows to reverse negative effects of vegetative encroachment or to transport sediment.

7. Develop partnerships to improve land management practices that may reduce water quality via runoff of contaminants or spills in all subbasins. This action protects stream water quality.

8. Operate dams to provide appropriate release water temperatures to meet life history requirements, specifically from Flaming Gorge Dam, Navajo Dam, and the Aspinall Unit. This action should be continued at Flaming Gorge Dam or enacted where feasible at the other locations if water temperatures are a limitation in achieving demographic recovery criteria.

9. Expand Colorado pikeminnow access into the greatest feasible extent of historically occupied range. This action increases the species' resiliency, redundancy, and representation, recognizing that Colorado pikeminnow is currently limited to a small portion of its former range. Implementation of this action might include exploring opportunities to reintroduce the species, constructing additional passage or improvement projects, or modifying existing structures where access is a limitation to achieving demographic recovery criteria. Warmer stream temperatures from climate change and future management actions could lead to improved habitats outside the current distribution for Colorado pikeminnow. Periodic assessments should be conducted to

determine the suitability of additional reaches to contribute to recovery of the species, particularly in the LCRB.

10. Prevent escapement of invasive fishes from source populations by constructing exclusion facilities, replacing invasive species in reservoirs with compatible sport fisheries, and eliminating sources where possible. This action reduces threats posed by the expansion of nonnative species into current range of Colorado pikeminnow.

11. Reduce illicit and unintentional movements of all invasive taxa that could become established in Colorado pikeminnow current range by conducting outreach, enacting regulations where needed, and enforcing regulations. This action reduces the risks posed by the introduction or establishment of additional invasive species.

Table 3. Factors affecting the survival of Colorado pikeminnow (Service 2020, pp. 16–18) and associated recovery actions and criteria.

Listing Factors under the Act	Threats Description	Recovery Actions	Recovery Criteria
Factor A- *The present or threatened destruction, modification, or curtailment of its habitat or range*	Habitat degradation and fragmentation due to water development	1, 2, 6, 8, 9	1, 2, 3, 4, 5, 6
Factor C- *Disease or predation*	Predation	3, 10,11	3, 4, 5
Factor E- *Other natural or manmade factors affecting its continued existence*	Small population size and extirpation in some basins	4	1, 2
	Climate change	1, 2, 6, 8	5, 6
	Contaminants	7	2, 3, 4
	Reduced forage base	5	2, 5, 6

IV. Estimated Time and Costs to Achieve Recovery

We summarized the estimated time and costs to achieve recovery of Colorado pikeminnow (Table 4). The values are derived from projected time and costs for actions similar to those described as recovery actions above and do not account for possible future inflation. The specific activities to be implemented are described in more detail in the Recovery Implementation Strategy, which can be updated and revised as needed. While this plan and the associated estimates are based on actions needed to recover Colorado pikeminnow specifically, most of the actions will also provide benefits to other listed and native fishes of the Colorado River basin. We estimate that the full implementation of these actions would improve the status of Colorado pikeminnow and could be completed approximately 15 years following the adoption of this plan. We note that the recovery program may change over time, or the timeframe estimated to implement the recovery actions to achieve recovery of the species may take longer than expected. Many of the recovery actions described in this plan address threats to the species and will need to continue beyond delisting so that these threats do not reverse progress made in

recovering the species. Finally, Federal, state, non-governmental organizations (NGOs), and local stakeholders direct a suite of additional activities that, while not specifically directed at Colorado pikeminnow, further contribute to recovery of the species. These activities are not part of the estimated costs and may include efforts such as improving water quality, managing water supplies and timing of flows, protecting water rights, and restoring ecosystem functions.

Table 4. Estimated time and costs of recovery actions for the recovery of Colorado pikeminnow.

Costs ($1,000s) and Time Frames (Years)					
Recovery Action	**Action Summary**	**Implementation Timeframe**			
		Years 1–5	**Years 6–10**	**Years 11–15**	**Total**
1	Manage flows	10,930	10,930	10,930	32,790
2	Operate and maintain fish passages	25,250	10,650	10,650	46,550
3	Control nonnative fishes	11,420	11,420	11,420	34,260
4	Develop and maintain broodstock	4,735	4,735	4,735	14,205
5	Conserve or improve forage base	3,690	3,690	3,690	11,070
6	Create and maintain habitats	2,165	4,340	2,165	8,670
7	Protect stream water quality	250	250	250	750
8	Operate dams for appropriate temperatures	200	0	0	200
9	Expand range	7,728	7,728	7,728	23,185
10	Prevent escapement of nonnative fishes	5,165	1,165	1,165	7,495
11	Prevent introductions of new invasive species	215	215	215	645
Total		**71,748**	**55,123**	**52,948**	**179,820**

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VI. Glossary

Term	Definition
Catastrophic	The outcome of a wide-ranging event that may result in the loss of one or more populations.
Extirpated	The local extinction of a species, where it ceases to exist in a particular area but continues to exist elsewhere.
Hypolimnetic	Originating from a layer of water in a thermally stratified lake or reservoir. The hypolimnion layer is deeper in the water, does not circulate, and maintains colder temperatures.
Piscivorous	A description for an animal that primarily or exclusively feeds on fish.
Redundancy	The number of populations or sites necessary to endure catastrophic losses (Shaffer and Stein 2000, pp. 308–10).
Representation	The genetic diversity necessary to conserve long-term adaptive capability (Shaffer and Stein 2000, pp. 307–308).
Resiliency	The size of populations necessary to endure random environmental variation (Shaffer and Stein 2000, pp. 308–310).
Species viability	A species' ability to sustain populations in the wild beyond the end of a specified time period, assessed in terms of its resilience, redundancy, and representation (Service 2016).
Stochastic	Random or non-deterministic events. Can also refer to natural changes in genetic composition of a population, unpredictable fluctuation in environmental conditions, or variation in population demographics (Service 2016).
Turbidity	A measure of a liquid’s clarity as a result of suspended particles.
Viability	See “Species Viability” above

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Appendix A – Summary of Public and Partner Comments

On November 28, 2022, we published a notice of availability of the Colorado pikeminnow (*Ptychocheilus lucius*) draft recovery plan for public review and comment, and to solicit comments by the scientific community, state and Federal agencies, tribal governments, and other interested parties on the general information, assumptions, and conclusions presented in the draft recovery plan. We also conducted additional outreach to announce the availability of the draft recovery plan for review, and we posted an electronic version of the draft recovery plan on our Species Profile website (*https://ecos.fws.gov/ecp/species/3531*).

During the public comment period, we received comments from three state agencies and one non-governmental organization. Overall, all commenters expressed support for the draft recovery plan, and one commenter indicated the recovery criteria are clear, measurable, and represent the most recent scientific information. We reviewed all comments for any substantive issues identified in the draft recovery plan and any new information regarding Colorado pikeminnow. We incorporated substantive comments in the final recovery plan, as needed. Below, we summarize the comments that we received and our responses. All substantive information provided during the comment period has been incorporated directly into the final recovery plan, as appropriate, or is addressed below.

1. *Comment*: We received several comments questioning whether the sequential numbering of the recovery actions in the draft recovery plan indicated their importance or priority, and if so, recommended that we reconsider the detailed prioritization of the recovery actions.

   Our Response: The specific, sequential numbers assigned to the recovery actions in this recovery plan are for identification purposes only and do not reflect an assigned rank or priority. Instead, as required by the Act and our September 21, 1983, Listing and Recovery Priority Guidelines (48 FR 43104), recovery actions are grouped as Priority 1 and 2 actions, and all the recovery actions under a given priority have the same priority ranking, regardless of their identification number. We have clarified in the appropriate section of recovery plan under the recovery actions sections. This clarification also applies to the recovery activities in the recovery implementation strategy (RIS).

2. *Comment*: A commenter suggested that we add a section to the recovery plan that summarizes the impacts of climate change to Colorado pikeminnow and that describes the interaction between climate change and the other stressors that may affect the species.

   Our Response: The species status assessment (SSA) report, which provides the scientific foundation and support for this recovery plan, includes a detailed discussion on climate change and its potential effects on the species and its habitats and its interactions with other stressors (Service 2022, pp. 41–44). The SSA report also summarizes other stressors and conservation efforts that may affect the species (Service 2022, pp. 28–82). Under our three-part recovery planning and implementation (RPI) framework, housing the scientific information on the species and its stressors in the updatable SSA report improves the effectiveness, efficiency, and flexibility of the recovery plan. Please see the SSA report for this discussion.

3. *Comment*: One commenter recommended the recovery plan detail the movement of Colorado pikeminnow between the Green and Upper Colorado river subbasins and how to account for such movements.

   Our Response: The SSA report discusses what is currently known about interbasin movements of Colorado pikeminnow between the Green and Colorado rivers (Service 2022, pp. 25–26, 87–100, 123–125). To summarize here, most movement appears to be adult Colorado pikeminnow leaving their home ranges to spawn. Current monitoring for adult abundance in both rivers is designed to estimate the number of resident adults in each subbasin before most movements are likely to occur. We believe the current monitoring program reflects the abundance of resident fish within each subbasin. This adult monitoring, in addition to subbasin-specific monitoring for younger life stages, will adequately capture movements of fish, assess the contribution of migration to subbasin populations, and inform whether progress is being made in achieving the recovery criteria.

4. *Comment*: A commenter suggested the recovery plan identify nonnative species of concern.

   Our Response: The SSA report provides greater detail and identifies specific nonnative species (Service 2022, pp. 34–36, 72–80). Although the diversity of nonnative species may vary between subbasins and may change over time, their influence on the recovery of Colorado pikeminnow remains the same. Therefore, identifying specific nonnative species in the recovery plan is unnecessary. This also provides the recovery partners the flexibility to adapt the associated recovery actions to each subbasin, to respond to shifting dynamics and locations of nonnative species, and to react to introductions of new species. The RIS may provide additional species-specific information for the recovery activities that address nonnative species, as needed.

5. *Comment*: A commenter recommended the recovery plan give more consideration to conservation and restoration of riparian and floodplain habitat. The commenter also suggested that we include additional recovery actions, such as protections that may promote the conservation of these habitats.

   Our Response: The recovery plan outlines recovery actions intended to maintain or create habitats using flows or other methods, which would help conserve and restore these habitats. Although Colorado pikeminnow do use floodplain areas to some extent, we have prioritized the maintenance of channel complexity, backwater quantity and quality, and spawning substrates to improve the resiliency of Colorado pikeminnow populations.

EXHIBIT 37

U.S. Fish and Wildlife Service

Species Status Assessment for the Humpback Chub (*Gila cypha*)



Fish Illustration © Joseph. R. Tomelleri

U.S. Fish and Wildlife Service
Mountain-Prairie Region (6)
Denver, CO

Version 1.1

Cover Illustration of Humpback Chub © Joseph R. Tomelleri, Americanfishes.com

*Version 1.1 of the SSA includes an update to section 2.2 to clarify historical and current distribution through 2018. It also includes minor grammatical and formatting changes. These updates do not change the scientific analysis or conclusions within the report.

Recommended reference:

U.S. Fish and Wildlife Service. 2018. Species status assessment for the Humpback Chub (*Gila cypha*). U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, CO. Version 1.1.

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EXECUTIVE SUMMARY

This Species Status Assessment (SSA) provides an integrated assessment of the status of the Humpback Chub (*Gila cypha*) across six populations (five extant populations and one recently considered functionally extirpated). The SSA first establishes the essential requirements of Humpback Chub by describing the species and its resource needs. Next, the SSA evaluates the current condition of the resources, ongoing conservation actions, and recent demographic information to describe the current condition of the species under existing environmental and anthropogenic factors. To assess potential future condition, the SSA forecasts the species' response to multiple probable future scenarios under a biologically meaningful timeframe. Considering the uncertainties of each future scenario, the species is evaluated within the context of resiliency, redundancy, and representation.

Species Overview

The Humpback Chub is a fish endemic to the warm-water portions of the Colorado River system of the southwestern United States. Collections show that the Humpback Chub inhabits disjunct canyon areas characterized by rocky habitat and swift currents. Humpback Chub are resilient to a variety of physical and chemical habitat conditions and tolerate a wide range of river flows at all life stages. Individuals can live up to 20 years (up to 40 years in the lower basin), reach sexual maturity around age 5, and can produce up to 2,500 eggs annually. The Humpback Chub has a variable diet, such that individuals consume a large array of food items under different river conditions.

The historical range of the species includes portions of the Colorado, Green, and Yampa rivers, but this range has been reduced through the construction of mainstem dams in canyon areas. Two of eight documented populations of Humpback Chub are extirpated because of the construction of Flaming Gorge (Hideout Canyon) and Hoover dams (Black Canyon). The species is now found as five extant populations, including four upstream of Lake Powell (Black Rocks, Westwater Canyon, Desolation/Gray canyons, and Cataract Canyon) and one downstream of Lake Powell (Grand Canyon). A sixth population in Dinosaur National Monument (DNM) is considered functionally extirpated because individuals have not been collected since 2004. Humpback Chub are now managed as two units, the 'upper basin' and 'lower basin', separated by Glen Canyon Dam.

Species Needs

The species' life cycle is described as seven life stages including spawning, eggs, larvae, age-0, juveniles, sub-adults, and adults. During each life stage, the species requires certain

resource conditions to successfully move to the next stage. This SSA summarizes the following eight categories, which are considered the most important for species success:

1. Diverse rocky canyon river habitat for spawning, nursery, feeding, and shelter.
2. Suitable river flow and temperature regimes for spawning, egg incubation, larval development, and growth.
3. Adequate and reliable food supply, including aquatic and terrestrial insects, crustaceans, and plant material.
4. Habitat with few nonnative predators and competitors that allow the young to survive and recruit to maintain self-sustaining populations.
5. Suitable water quality with few contaminants and little risk of spills of petroleum products and other toxic materials.
6. Unimpeded range and connectivity that allow free movement and access to habitats necessary for all life stages.
7. Persistent populations, each with reproductive potential, recruitment, and adult survival, to ensure redundancy.
8. High genetic diversity within and across populations to maintain and ensure adaptive traits.

Current Condition

The current condition of the Humpback Chub is derived by considering the current resource conditions, ongoing management actions, and population monitoring (using intrinsic rate of growth, lambda [λ], when available). Resource conditions existing within each of the five extant upper basin populations are typically good to neutral (Table EX1; details in Table 7 in section 4.3). The upper basin populations generally have high quality rocky canyon habitat, suitable temperature, adequate food base, unimpeded connectivity, and high genetic diversity. The resources of highest concern and uncertainty are adequate flow regimes, the existence of nearby populations of nonnative fish, and intrinsic growth rates that do not indicate population growth. Management actions have been enacted over the last decade, including implementation of flow and temperature regimes (Table 4 in section 4.1) and nonnative fish removal (Table 8 in section 4.4). The extirpation of the Dinosaur National Monument population, likely caused by multiple flow related stressors over many decades after the construction of Flaming Gorge Dam, has decreased the genetic diversity in the upper basin.

In the lower basin, Humpback Chub have high quality canyon habitat, unimpeded connectivity to mainstem habitats, and high generic diversity. River flow, water temperature, food supply, and predation/competition are the key factors controlling the lower basin population (Table EX1; details in Table 7 in section 4.3). Glen Canyon Dam causes resource

conditions in the lower basin to be markedly different than in the upper basin because temperature and food availability are influenced by cold water releases. Current flow releases from Glen Canyon Dam are prescribed under the Long-Term Experimental and Management Plan EIS (LTEMP EIS) and are designed to minimize impacts on canyon resources. In addition, management actions such as translocations and nonnative fish management of adult Humpback Chub are enacted to support the species (Table 9 in section 4.3).

Table EX1. A summary of the current condition of species needs for the six populations of the Humpback Chub. [For more detail descriptions of resource conditions, see Table 7 and sections 4.1 and 4.2.]. Color codes: dark green = resource condition is good, light green = fair; yellow = neutral, orange = poor; red = bad.

Resource Category	Upper Basin					Lower Basin
	Black Rocks	**Westwater Canyon**	**Desolation/ Gray canyons**	**Cataract Canyon**	**Dinosaur National Monument**	**Grand Canyon**
	Extant				Extirpated	Extant
1. Diverse rocky canyon river habitat						
2a. Suitable flow						
2b. Suitable temperature						
3. Adequate and reliable food supply						
4. Habitat with few nonnative predators and competitors						
5. Suitable water quality						
6. Unimpeded range and connectivity						
7. Persistent populations						
8. High genetic diversity						

Status of Populations

Status of a population is assessed using both catch rates (catch per unit effort [CPUE]) and mark-recapture estimates to maximize data available. Adult abundances and resultant population trajectories in upper basin populations vary. Abundance estimates of adult Humpback Chub are available for individual populations within the upper basin at varying frequencies over the last 17 years (1998–2015), though not annually for any single population (Table 10). Annual abundance estimates exist from 1989–2012 in the Grand Canyon, although model differences prevent estimate comparison before and after 2008 (Table 13 and section 4.5.6).

Upper Basin Populations

- Black Rocks and Westwater Canyon show similar patterns of population trajectory, with highest estimates in early monitoring (1998–2000) that declined through 2007. Evidence suggests that since 2007, declines have potentially been arrested and populations are stabilizing, although there is uncertainty about this hypothesis.
- Abundance estimate data is insufficient to reach any reliable conclusion about the trajectory of the Desolation/Gray canyons population; however, less rigorous, catch based monitoring starting in 1985 potentially demonstrates stability over 30+ years.
- The Cataract Canyon population is small and the trajectory of adult numbers is unclear; it is likely to persist based on consistent catch of adult and young life stages.
- The Dinosaur National Monument population is currently below detection limits and is now considered functionally extirpated, with the last capture occurring in 2004.

Lower Basin Populations

- The Grand Canyon population has a large core of 11,500–12,000 adults in the Little Colorado River that has likely remained relatively stable since 2008.
- Earlier estimates documented a substantial decline around the 1990s, followed by a strong increase in the 2000s. The number of adults in the Little Colorado River core population decreased from 10,946 in 1989 to 5,021 in 2001, and then increased to 7,650 in 2008. Recent research estimates these estimates are biased low by 20-30% because models did not include skip-spawning life history trait.
- In addition to the core population in and near the Little Colorado River, there are ~250 adults and several hundred juveniles and sub-adults distributed in ~408 km of the mainstem, with evidence of reproduction in western Grand Canyon.
- The presence of Humpback Chub and evidence of successful recruitment in western Grand Canyon has important implications as an extension of the core population, or possibly as a second reproducing population in the Grand Canyon.
- Successful translocation efforts in the Little Colorado River and Havasu Creek have expanded the range of the species into new habitats. Furthermore, spawning has also been documented with translocated fish in Havasu Creek.

Evaluation of Future Condition

The future condition of the Humpback Chub is derived by considering the future resource conditions for each population. For the purpose of this SSA, the future condition is evaluated at a biologically meaningful timeframe of 16 years, which corresponds to approximately two generation times in the upper basin (<2 in the lower basin because of higher adult survival).

In order to incorporate uncertainty about predictions of future conditions, the U.S. Fish and Wildlife Service selected three possible future scenarios of ecological conditions. The Science Advisory Team then evaluated the changes in ecological condition and resultant changes in resource conditions under each scenario.

The assessment of current condition determined that stream flow and predation/competition from nonnative fish are key factors controlling upper basin populations; whereas, stream flow, water temperature, food supply, and predation/competition from nonnative fish are key factors for the lower basin population. Potential future scenarios focus on those resources. All future scenarios assume that the mean annual availability of water (snowpack and runoff) will be lower and that the risk of nonnative fish expansion is commensurately higher as well. That is, there is no indication that risks from these two stressors will decline without management intervention. The three future scenarios do include varying levels of risk from changing conditions and consider varying implementation and effectiveness of active and adaptive management.

The three scenarios selected by the Service and evaluated by the Science Advisory Team are:

- Scenario 1 [Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated]- This scenario includes elimination of some active and adaptive actions, and a reduction in voluntary management actions for the species, such that many stakeholder actions are no longer in place to mitigate future conditions including decreased water availability, future water development, or nonnative fish. Conservation actions codified under binding agreements (NEPA, Section 7) would continue. For example, instream flows would not be legally protected any more than they are today (e.g. RODs, PBOs remain in effect), some voluntary flow management actions would diminish, and nonnative fish management would not continue in the upper basin. In the lower basin, water management, nonnative fish control, and other actions would remain consistent with the current level of effort prescribed by various RODs and Section 7 consultations, but no new or adaptive actions would take place. Although a greater proportion of actions in the lower basin are legally required, in this scenario it is expected that management actions are not adaptive or effective and unable to respond to the impacts from various stressors causing population declines of Humpback Chub in both basins.

- Scenario 2 [Legally Mandated Management Actions and Additional Adaptive Management Actions Occur, but are Ineffective] - In addition to minimum actions

required under Scenario 1, this scenario provides additional proactive and adaptive stakeholder management practices into the future; however, these actions are unable to mitigate impacts of drought, future water development, nonnative fishes, or other threats. For example, water operations cannot provide adequate flows or temperatures in Humpback Chub habitats because drought or other factors have decreased water supply, or nonnative fish colonize Humpback Chub habitat in high densities despite stakeholder action. In this scenario, it is expected that management actions respond to the impacts from various stressors but are not effective to prevent Humpback Chub declines.

- Scenario 3 [Legally Mandated Management Actions and Adaptive Management Actions Occur, and Are Effective] - In addition to minimum actions required under Scenario 1, this scenario provides additional proactive and adaptive stakeholder agencies' management practices into the future for the species, and these actions are sufficient to mitigate impacts of drought, future water development, nonnative fishes, or other threats. For example, water operations have the flexibility to provide adequate flows and temperatures to and nonnative fish do not colonize or are effectively managed in Humpback Chub habitat. In this scenario, it is expected that management actions respond to the impacts from various stressors causing population declines, and are adequate to stabilize and increase Humpback Chub populations.

Potential Future Conditions

For each of the potential future scenarios, the overall effect expected to occur within each population is described in sections 5.3.1, 5.3.2, and 5.3.3. Conditions of species needs are summarized in Table EX2, with details provided in Tables 16, 17 and 18 for Scenarios 1, 2, and 3 respectfully. Conditions under scenario 1 are largely poor and bad and do not support Humpback Chub needs. Conditions improve greatly in scenario 2, although flow, nonnative fish management, and food (in the Grand Canyon) are still not sufficient. Under scenario 3 conditions improve to provide Humpback Chub with conditions that are sufficient for the species.

Under scenario 1, the increased threat of reduced water availability and existing nonnative fish populations are not mitigated with any additional actions that are not currently legally mandated. In the upper basin rocky canyon habitat, suitable temperature, adequate food supply, and connectivity of populations are largely still provided, and catastrophic low flows are prevented through the operation of Bureau of Reclamation facilities under existing RODs. However, the lack of water supply and adaptive flow management increases frequency of drier hydrologies, diminishing habitat quality for Humpback Chub. Even more consequentially, drier hydrologies and lack of nonnative fish removal likely allows established nonnatives, especially Smallmouth Bass, to expand into Humpback Chub areas such as Desolation / Gray canyons and Black Rocks. Under all of these stressors, it is expected that at least one upper basin population would become extirpated and others would

decrease in abundance quickly, thus also straining the genetic diversity of the upper basin. In the lower basin, the physical habitat will remain intact and flow regimes are already in place. However, temperature, food supply, and nonnative fish conditions would worsen for Humpback Chub. Predation/competition by Rainbow Trout and Brown Trout is likely to continue and other warm-water species may increase in impact. Effects of groundwater pumping are largely unknown, but could have dire consequences for the core Little Colorado River population.

Under scenario 1, conditions in both the upper and lower basin are expected to strain the resiliency of Humpback Chub with poor resources conditions. The upper basin will likely see dramatic population declines, will likely lose another population to extirpation, and cannot re-establish the Dinosaur National Monument population. The core lower basin population in the Little Colorado River is expected to continue to reproduce and recruit annually, but be less resilient than it is currently. The current population size protects the core population from a variety of potential threats.

Under scenario 2, the increased threat of reduced water availability and existing nonnative fish populations are mitigated with additional actions but those actions are not effective. In the upper basin, rocky canyon habitat, suitable temperature, adequate food supply, and connectivity of populations are largely still provided, and catastrophic low flows are prevented. Under existing RODs, the Bureau of Reclamation provides some adequate flows and with minor increases in frequency of drier hydrologies, habitat quality for Humpback Chub diminishes. Ineffective nonnative fish removal cannot prevent established nonnative fish, especially Smallmouth Bass, to slowly expand into Humpback Chub areas such as Desolation / Gray canyons. Upper basin populations slowly decrease in abundance, putting the genetic diversity of the upper basin at risk if multiple populations within a genetic grouping are simultaneously nearing extirpation. In the lower basin the physical habitat will remain intact and flow regimes are already in place. However, temperature, food supply, and nonnative fish conditions could worsen for Humpback Chub. Implementing actions to improve food production and prevent expansion of nonnative would be ineffective. Predation/competition by Rainbow Trout and Brown Trout is likely to continue. Genetic diversity is expected to persist, and a second reproduction center in the western Grand Canyon may occur under this scenario.

Under scenario 2, conditions in the upper and lower basin slowly decrease in quality because additional and adaptive stakeholder actions are insufficient to mitigate the impacts. For example, in the upper basin, nonnative fish control is implemented, but does not prevent expansion of Smallmouth Bass. In the lower basin, food supply may be limited and additional tools to manage nonnative fish are not effective. In the upper basin populations are likely to steadily decline because of limited recruitment and unsuccessful attempts to re-establish the Dinosaur National Monument population. In the lower basin the core Little Colorado River population continues to recruit, but areas outside may be reduced.

Table EX2. A summary of the future condition of species needs for the six populations of the Humpback Chub under three potential future scenarios. [For more detailed descriptions of resource conditions, see Table 16, 17, and 18 and sections 5.3.1, 5.3.2, and 5.3.3.] Color codes: dark green = resource condition is good, light green = fair; yellow = neutral, orange = poor; red = bad.

Resource Category	Scenario 1: Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated						Scenario 2: Legally Mandated Management Actions and Additional Adaptive Management Actions Occur, but are Ineffective						Scenario 3: Legally Mandated Management Actions and Adaptive Management Actions Occur, and Are Effective					
	Details Found in Table 16						Details Found in Table 17						Details Found in Table 18					
	BR	WW	DG	CC	DNM	GC	BR	WW	DG	CC	DNM	GC	BR	WW	DG	CC	DNM	GC
1. Diverse rocky canyon river habitat																		
2a. Suitable flow																		
2b. Suitable temperature																		
3. Adequate and reliable food supply																		
4. Habitat with few nonnative predators and competitors																		
5. Suitable water quality																		
6. Unimpeded range and connectivity																		
7. Persistent populations																		
8. High genetic diversity																		

Under scenario 3, the increased threat of reduced water availability and existing nonnative fish populations are mitigated with additional actions that successfully improve Humpback Chub condition. In the upper basin, rocky canyon habitat, suitable temperature, adequate food supply, and connectivity of populations are provided, and sufficient inter- and intra-annual flow variability is provided under existing RODs. Nonnative fish removal suppresses existing population expansions, especially for Smallmouth Bass. Upper basin populations slowly stabilize or increase in abundance with improved recruitment. The genetic diversity of the upper basin is maintained. In the lower basin the physical habitat will remain intact and flow regimes are already in place. Temperature, food supply, and nonnative fish conditions could improve for Humpback Chub with implementation of new actions. Although predation/competition by Rainbow Trout and Brown Trout is likely to continue, impacts do not alter the demographics of Humpback Chub. Genetic diversity is expected to persist, and a second reproduction center in the western Grand Canyon likely occurs under this scenario.

Under scenario 3, conditions in the upper and lower basin that have improved Humpback Chub condition over the past decade or more are continued, are effective, and are expanded as needed. In the upper basin, nonnative fish management prevents expansion of Smallmouth Bass and supplies adequate flow regimes for strong recruitment. In the lower basin, food supply, temperature regime, and nonnative fish are appropriately managed with additional tools. Persistent populations in the upper basin become stable or increase and the Dinosaur National Monument population is potentially re-established. In the lower basin, the core Little Colorado River population continues to be stable and Humpback Chub expand its range within the Grand Canyon.

Species Viability

To characterize species viability, the principles of resiliency, redundancy, and representation are used to summarize resource conditions, biological traits, population demographics, and genetic diversity. Resiliency describes the ability of individuals and populations to withstand environmental or demographic stochasticity. Redundancy describes the ability of populations to withstand catastrophic events in a way that spreads risk and minimizes potential loss of the species. Redundancy is characterized as having multiple, resilient populations distributed across the range of the species. Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations.

Humpback chub have many traits that enable individuals to be resilient in the face of environmental or demographic stochasticity including long life span, high reproductive potential, use of habitats and turbidity that are arduous to other species, adaptation to a wide variety of flow and thermal regimes, and a variable omnivorous diet. Population resiliency is demonstrated by a variety of traits including persistence of small populations (Cataract Canyon), population increases over many years of decline (Grand Canyon), increases after translocations (Havasu Creek), and potential stabilization of declines (Black Rocks and

Westwater Canyon). In addition, the current population size of the Grand Canyon protects it from a variety of potential threats.

The current distribution of the Humpback Chub provides a sufficient level of redundancy, albeit at a near-minimal level. Existing populations have independent susceptibility to threats by occurring in different river basins. New populations are being discovered (western Grand Canyon) or established (Havasu Creek) in the lower basin, and are being considered (Dinosaur National Monument) in the upper basin. This redundancy also assists with representation, as all genetic diversity of the species occurs in multiple populations, except the very large Grand Canyon population. In the upper basin, exchange of individuals is sufficient to ensure genetic diversity.

Considering these individual and population traits, the current condition of resource needs, and the potential future condition of resource needs, the Science Advisory Team evaluated expected condition of resiliency, redundancy, and representation at the biologically meaningful timeframe under the three potential future scenarios described by the U.S. Fish and Wildlife Service (summarized in Table EX3, with detailed conditions in Tables 19 and 20). In the upper basin, scenario 1 provides bad conditions for Humpback Chub, while scenario 2 provides poor to neutral conditions, and scenario 3 provides fair conditions that support the species. In the lower basin, scenario 1 provides poor resiliency and neutral redundancy, but all other conditions in the lower basin are fair to good in all three scenarios. This demonstrates that the resiliency, redundancy, and representation of the five extant upper basin populations are much more tenuous and impacted by management effectiveness than the lower basin population.

Table EX3. A summary of resiliency, redundancy and representation under the three future scenarios presented above for the upper and lower basins.[For more detail descriptions see Tables 19 and 20 and section 6.2] Color codes: dark green = good, light green = fair; yellow = neutral, orange = poor; red = bad.

		Resiliency	Redundancy	Representation
Upper Basin	S1			
	S2			
	S3			
Lower Basin	S1			
	S2			
	S3			

It is apparent that the species is expected to be fairly well represented and resilient in the future under scenarios 2 and 3. Redundancy is less certain, but primarily because of the potential to see declines in upper basin populations under ineffective management actions. If management actions can prevent a loss of an additional upper basin population, or re-

establish the Dinosaur National Monument population (Scenario 3), conditions will be sufficient for the species.

Using these conclusions to consider species viability, species experts and the Service agree that based on the best available information, species viability is more tenuous in the upper basin than in the lower basin. One of the largest threats to the Humpback Chub, that of nonnative fish invasions, increases dramatically with time as invasions are difficult to predict – both in timing and extent of damage. In both scenarios 1 and 2, the potential effects of nonnative predation or competition indicate that the species may suffer declines within the foreseeable future. Scenario 3 is defined by the ability of management actions to react to and reduce the threat from these invasions, and thus shows species viability continuing on its current trend or possibly increasing over time.

Ongoing and future management could be sufficient to offset threats and promote survival and recruitment for 30 years, but some uncertainty surrounds future management activities. Although many conservation efforts in the Lower Basin are guaranteed for more than 50 years in the future, efforts in the Upper Basin have not been contracted beyond 2023 or funded beyond 2019. Uncertainty remains regarding current population trajectories of Humpback Chub, densities of nonnative predators in the upper basin, and risk associated with future conditions throughout the basin.

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1.0 INTRODUCTION

1.1 Overview and Report Organization

This Species Status Assessment (SSA) provides a consolidated description of the biological status of the endangered Humpback Chub (*Gila cypha*). This document is based on the best available scientific information and was prepared in accordance with the Species Status Assessment Framework of the U.S. Fish and Wildlife Service (2016a; Service). This SSA may be used by the Service to inform decisions about the species related to the Endangered Species Act (ESA). The ultimate goal of the SSA is to provide a clear description of species' needs, current condition, and response to probable future condition in order for the Service to determine the near-term and long-term viability of the species. This SSA does not replace or supplant species recovery plans or species status reviews.

This SSA is organized in the following sections with corresponding content:

- **1.0 Introduction:** report organization and description of species status assessment framework.
- **2.0 Species Overview:** species description and taxonomy, range and distribution, evolutionary history and genetics, and listing status.
- **3.0 Species Needs:** life history and resource needs that are most important to the species by life stage.
- **4.0 Current Condition:** controlling factors by life stage, condition of populations, ongoing management actions, and resource relationships that describe the current condition of the species.
- **5.0 Future Condition:** projection of populations under three future probable condition scenarios, and benefits of future conservation actions.
- **6.0 Species Viability:** characterization of species viability in terms of resiliency, redundancy, and representation.

A list of measures, acronyms, and abbreviations used in this document is provided in Appendix A. An assessment of future flow and temperature conditions is provided in Appendix B.

1.2 Species Status Assessment Framework

A Species Status Assessment provides a consistent, scientifically-based and conservation-focused assessment of the biological status of a species (USFWS 2016a). The SSA involves three assessment stages (Figure 1):

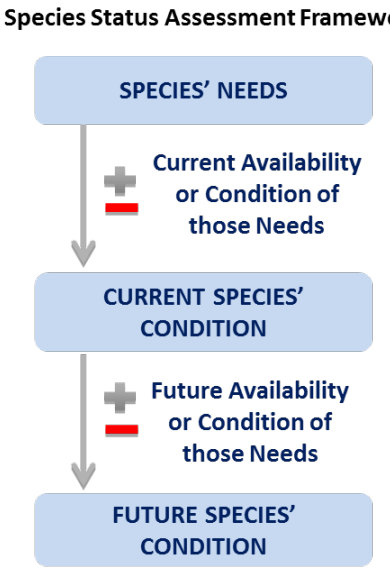


Figure 1. The Species Status Assessment Framework's three basic stages (USFWS 2016a).

1. **Species' Needs.** The first stage is a compilation of the best available biological information on the species (taxonomy, life history, and habitat) and its ecological needs at the individual, population, and species levels based on how environmental factors are understood to act on the species and its habitat.
2. **Current Condition.** The second stage describes the current condition of the species' habitat and demographics, and the probable explanations for past and ongoing changes in abundance and distribution within the species' ecological settings (i.e., areas representative of the geographic, genetic, or life history variation across the species' range).
3. **Future Condition.** The last stage forecasts the species' response to probable future scenarios of environmental conditions and conservation efforts. As a result, the SSA characterizes species' ability to sustain populations in the wild over time (viability) based on the best scientific understanding of current and future abundance and distribution within the species' ecological settings.

This SSA is not a decision document. It is an analytical tool used by the Service for summarizing biological and ecological information that can help inform a variety of decisions and activities under the ESA, including recovery planning, 5-year status reviews, inter-agency consultations, and species reclassifications (Figure 2).

Conducting a Species Status Assessment involves compiling and analyzing the best available scientific information for the species. The SSA is a living, stand-alone, science-based document, independent of the application of policy or regulation. It provides foundational

biological information, articulates key uncertainties, and ultimately characterizes the species' current and future condition and viability under various scenarios and timeframes.

This SSA was done for the Humpback Chub in advance of the preparation of a species recovery plan and 5-year status review. The SSA process also provides a framework for development of recovery criteria in the species recovery plan.

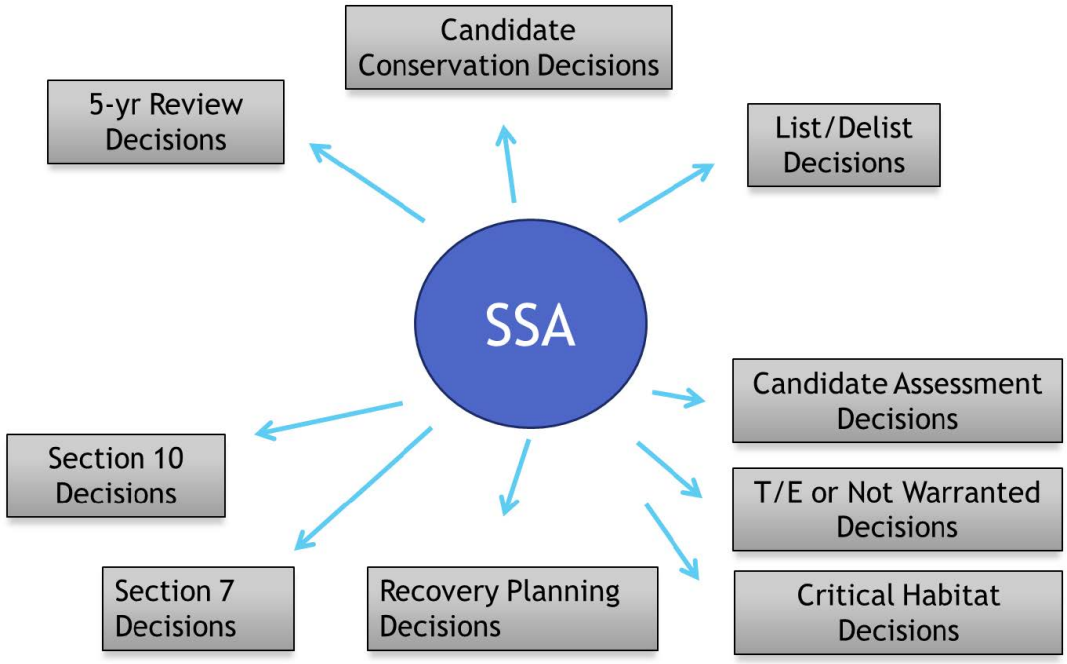


Figure 2. The Species Status Assessment Framework supports Endangered Species Act decisions (USFWS 2016a).

Throughout this SSA, the principles of resiliency, redundancy, and representation (3 R's) are used to characterize species viability and to ensure that the SSA is comprehensive and biologically sound. The 3 R's have a relationship to individuals, populations, and the species, as portrayed in Figure 3. The following is a description of the 3 R's (USFWS 2016a):

- **Resiliency** describes the ability of a species to withstand stochastic disturbance. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant individuals within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance.
- **Redundancy** describes the ability of a species to withstand catastrophic events; it's about spreading risk among multiple populations to minimize the potential loss of the species from catastrophic events. Redundancy is characterized by having multiple, resilient populations distributed within the species' ecological

settings and across the species' range. It can be measured by population number, resiliency, spatial extent, and degree of connectivity. Our analysis explores the influence of the number, distribution, and connectivity of populations on the species' ability to withstand catastrophic events (e.g., rescue effect).

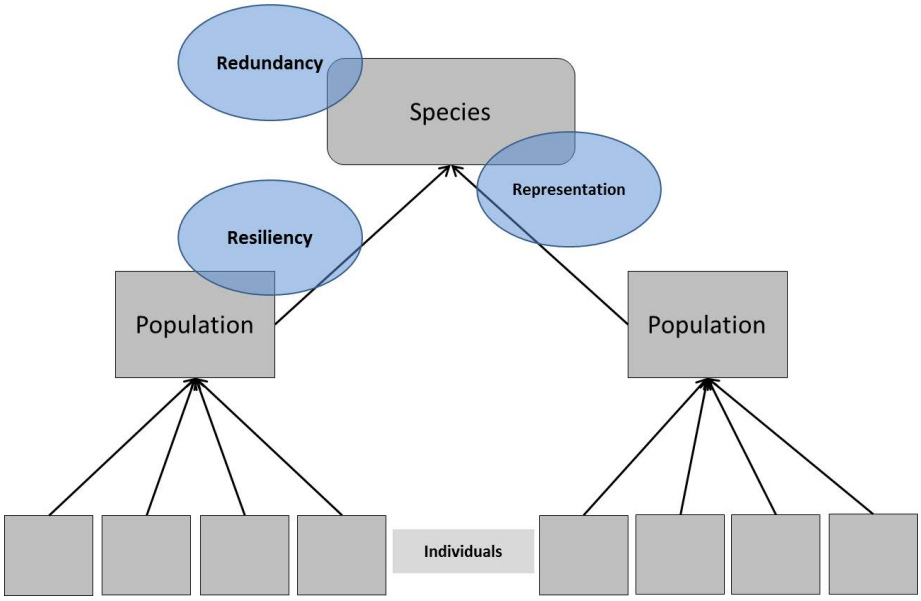


Figure 3. Relationship of resilience, redundancy, and representation at the individual, population, and species levels. Resiliency is measured at the population level, representation is measured at the species and, possibly, population level, and redundancy is measured at the species level. In practice the 3Rs are interrelated – resiliency supports redundancy, representation supports resiliency, etc. (USFWS 2016a).

- **Representation** describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, the gene diversity, heterozygosity or alleles per locus. Our analysis explores the relationship between the species life history and the influence of genetic and ecological diversity and the species ability to adapt to changing environmental conditions over time. The analysis identifies areas representing important geographic, genetic, or life history variation (i.e., the species' ecological settings).

2.0 SPECIES OVERVIEW

2.1 Description and Taxonomy

The Humpback Chub was described from a fish caught by angling in 1933 near Bright Angel Creek, a tributary of the Colorado River in Grand Canyon (Miller 1946), making it one of the last large fish species to be described in North American (Service 1979). The species is a member of the minnow family that attains a total length (TL) of ~480 mm and a weight of ~1.2 kg (Valdez and Ryel 1997). Juveniles have cylindrical bodies with a greenish back, silvery sides, and a whitish belly. Adults have an enlarged nuchal hump that rises abruptly behind the head and a laterally-compressed body that is fusiform and tapered toward a slender tail (Figure 4). The back and sides are grayish green fading to a whitish belly. The scales are small and deeply embedded, sparse toward the back, and absent from the nuchal hump and belly. The fins are large and falcate and the tail is deeply forked.

Spawning adults develop small protuberances or tubercles on the head and paired fins; and the gill coverings, paired fins, anal fin, and belly become tinged with orange. Dorsal and anal fins typically have 9 and 10 principal rays, respectively, and the pharyngeal arch is small with a short lower ramus and deciduous teeth in a typical pattern of 2,5–4,2 (Miller 1946). Examination of otoliths (Hendrickson 1993) and recapture data indicate that Humpback Chub frequently reach an age of over 20 years, with longevity of ~40 years (Coggins et al. 2006; STReaMS July, 2016).



Figure 4. Adult Humpback Chub in spawning condition (Photo courtesy of U.S. Geological Survey).

2.2 Range and Distribution

The Humpback Chub is a warm-water riverine fish species endemic to the Colorado River System of the southwestern United States. The exact historical range of the species is uncertain because the difficulty sampling its canyon habitats made it largely inaccessible to early researchers (Service 1979). In fact, until the 1950s the Humpback Chub was only known from the Grand Canyon; range descriptions of new populations continued into the 1980s (Valdez 1990). Because of this lack of historical fish sampling data, the best inferences for historical range can be made using paleontological evidence, reports and photographs by early explorers, and historical fish collections. Historical and recent collections have documented the species in the states of Arizona, Colorado, Utah, and Wyoming (Figure 5).

The Service estimated the historical range of the species was 2,180 km of river (1,354.6 mi) when designating critical habitat for the humpback chub in 1990, but recognized the historical distribution of the species was not well known (Final Rule Determination of Critical Habitat; 59 Fed. Reg. 13374). This estimated historical range includes intervening river reaches between canyon habitats in the upper basin that were likely migratory, but not residential areas for the species, and thus inflates the expected historical range of the species. Historical collections show that the Humpback Chub was found in disjunct canyon areas, reflective of contemporary collections and distribution (USFWS 2002). Therefore, the species' historical range can be generally described as canyon-bound, warm-water reaches within the Colorado and Green River subbasins, between the Colorado River from the Black Canyon near present-day Hoover Dam, AZ/NV, upstream to Debeque Canyon, CO; the Green River to the Blacks Fork River, WY; and the Yampa River through Cross Mountain Canyon, CO (Kolb and Kolb 1914; Miller 1946, 1955; McDonald and Dotson 1960; Smith 1960; Holden 1973).

Specific historical evidence indicates that the species occurred in eight locations, six in the upper basin and two in the lower basin (Table 1; Figure 5). Using best expert judgment, personal communications, and published reports, we estimated the range of humpback chub in these eight populations before dams and reservoirs were constructed. Using this information, the best estimate of the historical range of the species is 768.9 km (477.8 mi) of river (Table 1). The most widespread population is the Grand Canyon, where canyon-bound habitat is continuous and humpback chub have been documented throughout the canyon. Small enclave groups of fish have been documented in localized canyon-like reaches of the upper basin, such as Beavertail Bend and Elephant Canyon in the upper Colorado River (Valdez 1990); and the Little Snake River, a tributary of the Yampa River in Colorado (Wick et al. 1991), but resident populations cannot be confirmed in these locations.

The species is currently found in five locations, including four populations in the upper basin (Black Rocks, Westwater Canyon, Desolation/Gray canyons, and Cataract Canyon), and one population in the lower basin (Grand Canyon). Each the remaining populations consists of a discrete, geographically separate group of fish, with a few individuals moving among

populations at a decadal scale, based on genetic evidence (Douglas and Douglas 2007). One population in the upper basin (Hideout Canyon) and one in the lower basin (Black Canyon) were inundated by reservoirs and subsequently extirpated. A third population (Dinosaur National Monument, comprised of Yampa and Whirlpool canyons) was extirpated more recently around 2006.

Long-term sampling indicates extant populations have varying levels range reductions compared to historical distribution, although the exact range of humpback chub prior to the 1980s is not well documented (see references in Table 1). Range reduction in the Cataract Canyon population is the result of inundation of habitat by Lake Powell. The inundation of western Grand Canyon by Lake Mead also caused range reduction, although a declining elevations of Lake Mead has recently exposed this habitat and humpback chub have returned. Range reductions in Westwater and Desolation & Gray Canyons likely represent a contraction of humpback chub range as nonnative species began to inhabit reaches above and below canyon reaches. The Black Rocks population has not contracted in range.

Today, the five extant populations occupy approximately 525.3 km (326.4 mi) of river, or 68% of the historical 768.9 km (477.8 mi) (Table 1). In the upper basin, the species occurs in 33% of its historical habitat, largely the result of the extirpation of the Dinosaur National Monument population and contraction of the Cataract Canyon population. In the lower basin, the species occurs in 94% of its historical habitat because it is currently found throughout the Grand Canyon.

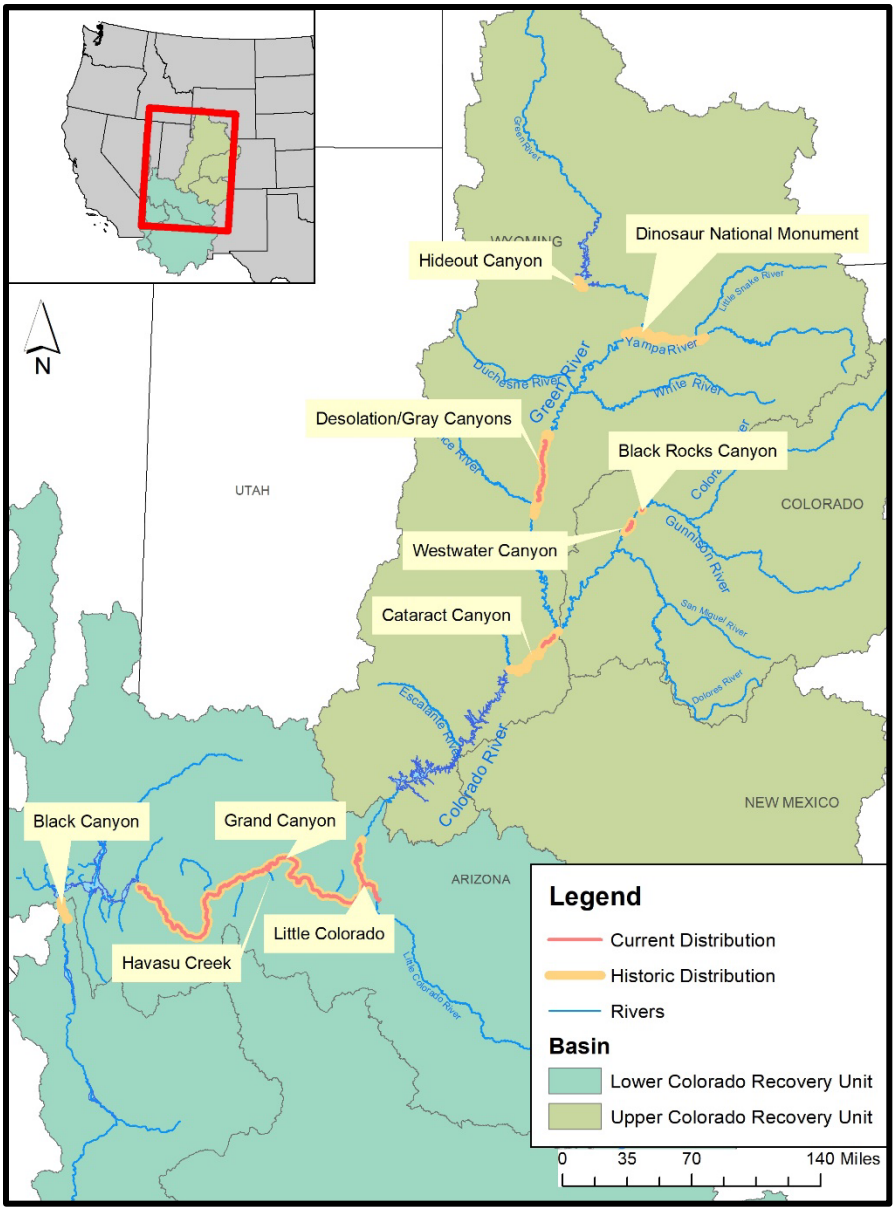


Figure 5. Current and historical distribution of the Humpback Chub.

Table 1. Estimated historical and present distribution of Humpback Chub populations. River Reaches with asterisks (*) are new translocation areas and are not considered in calculation of historical habitat.

Population	Historical		Present			Present Distribution		Reference
	Miles	Km	Miles	Km	Percent of historical	Begin River Mile	End River Mile	
Upper Basin								
1. Black Rocks, upper Colorado River, CO	1.0	1.6	1.0	1.6	100%	135.5	136.5	Kidd 1977; Valdez et al. 1982; Francis et al. 2016
2. Westwater Canyon, upper Colorado River, UT	10.0	16.1	8.4	13.5	84%	116.4	124.8	Valdez et al. 1982; Hines et al. 2016
3. Desolation/Gray canyons, Green River, UT	68.0	109.4	47.1	75.8	69%	142.9	190	Holden and Stalnaker 1970; Moretti et al. 1989; Badame 2012
4. Cataract Canyon, upper Colorado River, UT	38.9	62.6	11.0	17.7	28%	-14.5[d]	-3.5[d]	Valdez 1990; Badame 2008
5. Dinosaur National Monument[a]								
5a. Yampa Canyon, Yampa River, CO	60.0	96.5	0	0	-			Tyus 1998; Finney 2006
5b. Whirlpool Canyon, Green River, CO/UT	15.0	24.1	0	0	-			Vanicek 1967; Tyus et al. 1982; Tyus 1998; Bestgen & Irving 2006
6. Hideout Canyon, Green River, WY	10.0	16.1	0	0.0	-			McDonald and Dotson 1960; Smith 1960; Holden 1973
Upper Basin Subtotals:	202.9	326.4	67.5	108.6	33%			
Lower Basin:								
7. Grand Canyon, Lower Colorado River, AZ	253.5	408.0	250.5	403.1	99%	30	280.5	Valdez and Ryel 1995; Van Haverbeke et al. 2017
7a. Little Colorado River, AZ	8.4	13.6	8.4	13.6	100%	0	8.4	Kolb and Kolb 1914; Van Haverbeke et al. 2013
7b. Little Colorado River, AZ[b] —Above Chute Falls	0	0.0	2.7*	4.4*	-	8.4	11.1	Stone 2016
7c. Havasu Creek, AZ[c]	0	0	3.5*	5.6*	-			Trammell et al. 2012; Nelson et al. 2016
8. Black Canyon, Lower Colorado River, AZ/NV	13	20.9	0	0.0	-			Miller 1955
Lower Basin Subtotals:	274.9	442.5	258.9	416.7	94%			
Totals:	477.8	768.9	326.4	525.3	68%			

[a] This population is below detection limits and is now considered functionally extirpated. The last collection of humpback chub in this population were in the Yampa River in 2004 and in the Green River in 2006.

[b] A total of 2,971 juvenile Humpback Chub were translocated from the lower LCR to above Chute Falls (RK 13.57) during 2003–2015 (see section 4.5, Table 15).

c A total of 1,650 juvenile Humpback Chub were translocated from the LCR to lower Havasu Creek during 2011–2015 (see section 4.5, Table 15).

[d] Negative river miles indicate miles below the confluence between the Colorado and Green Rivers.

2.3 Evolutionary History

An overview of the evolutionary history of the Humpback Chub (*Gila cypha*) helps to inform contemporary population connectivity and exchange of individuals among populations. Systematic studies show that the Humpback Chub evolved as a species in canyons of northern Arizona (Grand Canyon) 3–5 million years ago (Holden 1968; Smith et al. 1979), during mid-Pliocene and early Pleistocene epochs, as the Colorado River was cutting through the Kaibab upwarp of the Colorado Plateau and joining the upper and lower basins (Bills et al. 2016). The Roundtail Chub (*Gila robusta*) and Bonytail (*Gila elegans*) appear to have evolved in the upper basin, but the Humpback Chub arose in response to the conditions of large erosive riverine habitats as a specialized derivative of the Roundtail Chub, as supported by allozyme and mitochondrial DNA linkages (Dowling and DeMarais 1993; Starnes 1995). It was suggested when the species was described that the enlarged nuchal hump, leathery skin, small embedded scales, torpedo-shaped body, and large falcate fins of the Humpback Chub are specialized adaptations to the swift, turbulent, silt-laden conditions of the Colorado River in Grand Canyon (Miller 1946).

Over time, the Humpback Chub dispersed from the Grand Canyon to other large canyon habitats of the Colorado River System, occupying primarily major rivers and large tributaries. Surrounding highlands in the Rocky Mountains underwent significant Pleistocene glaciation in the last 2 million years, and melting of these glaciers caused the Colorado River to flood and expand (Blakey and Ranney 2008), creating additional habitats and avenues for fish dispersal. Movement of Humpback Chub into the upper basin may have also been aided by the formation of large reservoirs created by lava flows that dammed the Colorado River in western Grand Canyon. At least 13 major lava dams have impounded the river in the last 1.8 million years, with the most recent ~400,000 years ago (Duffield 1997). The largest of these dams was at present-day Lava Falls Rapid (RM 179). At an estimated height of 610 m, this lava dam created a reservoir larger than modern-day Lake Powell (Glen Canyon Dam is 220 m high) that could have persisted for 3,000 years (Hamblin 1990). Shoreline deposits indicate that it extended as far upstream as modern-day Moab, UT, enabling fish to more easily disperse into the upper basin and eventually settle in isolated canyon reaches.

Paleontological evidence indicates that the ichthyofauna of the historical river and these ancient reservoirs was similar to the more recent native fish assemblage and consisted of 10 to 15 species—mostly cyprinids (minnows) and catostomids (suckers) (Miller 1959; Minckley et al. 1986). Remains of the Humpback Chub from high-elevation deposits of the Quaternary period (last 2.6 million years) indicate that the species was present when large portions of eastern Grand Canyon and Marble Canyon were inundated by the lava dam reservoirs (Miller 1955; Miller and Smith 1984). Survival strategies during this period are unclear, but the Humpback Chub apparently persisted in these ancient reservoirs, whereas, the species does not live in modern-day reservoirs, possibly because of the large number of contemporary nonnative predators that were otherwise historically absent.

The current distribution of the Humpback Chub in the upper basin, as disjunct canyon-confined populations, can be plausibly explained as a consequence of speciation in the rigorous conditions of the Grand Canyon, followed by long-term dispersal to present-day habitats with similar geomorphic and hydraulic features. Although the Humpback Chub is a comparatively weak swimmer (Bulkley et al. 1982) and is not known as a long-distance migrator, its ability to make limited movements through swift currents (Paukert et al. 2006) has enabled the species to disperse locally to find suitable habitat under changing conditions. Because the Humpback Chub speciated in large erosive riverine habitats, its distribution in the upper basin is defined by the occurrence of canyon-confined areas within warm-water regions, and there is no evidence to suggest that the species was ever found equally abundant in intervening sand-bed reaches. The life history of the species and habitat use show that the Humpback Chub does not rely on sand-bed river reaches or floodplains, as do the other native species of the basin, including the Colorado Pikeminnow and Razorback Sucker.

Historical and contemporary distributional information, habitat associations, and genetic linkages provide a compelling case for the Humpback Chub historically occupying disjunct canyon areas with little movement of individuals among populations. Thus, connectivity among these populations is principally genetic at a decadal scale (Douglas and Douglas 2007), with little demographic exchange and interdependence. The disjunct distribution pattern and low level of exchange among populations have a significant bearing on resiliency, redundancy, and representation, as discussed in section 6.2 of this document.

2.4 Genetics and Hybridization

The Humpback Chub is a member of the *Gila* complex, a group of western cyprinid fishes that inhabit the rivers and streams of the arid southwestern United States. Species of the *Gila* complex show morphologic and genetic similarities, but display considerable phenotypic plasticity in different environments within and among species. Three species of the genus *Gila* inhabit the mainstem Colorado River and live sympatrically in some regions, including:

1. Humpback Chub (*Gila cypha*);
2. Bonytail (*Gila elegans*); and
3. Roundtail Chub (*Gila robusta*).

Four additional congeneric species and subspecies are isolates and primarily tributary inhabitants with little or no historical or present interaction with the Humpback Chub, including:

1. Virgin River Chub (*Gila robusta seminuda*);
2. Pahranagat Roundtail Chub (*Gila robusta jordani*);
3. Gila Chub (*Gila intermedia*); and
4. Headwater Chub (*Gila nigra*).

The Humpback Chub, Roundtail Chub, and Bonytail are historically sympatric mainstem species with substantial evidence of introgressive hybridization (Dowling and DeMarais 1993). This hybridization has resulted in high phenotypic plasticity with morphologic intergrades in all sympatric populations (Holden and Stalnaker 1970; Smith et al. 1979; McElroy and Douglas 1995; Douglas et al. 1998) that now occur only in the upper basin. Alleles characteristic of Bonytail and Roundtail Chub are present in the Grand Canyon (Douglas and Douglas 2007), where the three species no longer coexist, but were collected in the early 1940s (Bookstein et al. 1985).

In 2016, the American Fisheries Society and the American Society of Ichthyologists and Herpetologists Joint Committee on the Names of Fishes determined that the Gila Chub and the Headwater Chub are part of a single taxon—the Roundtail Chub—and the Service subsequently withdrew a proposal to separately list the Headwater Chub and the Roundtail Chub (Federal Register Vol. 82, No. 66, April 7, 2017, 16981). The Committee did not evaluate the taxonomic status of the other *Gila* species, and the Humpback Chub, Roundtail Chub, and Bonytail continue to be considered valid taxonomic species.

An examination of the genetic structure of the Humpback Chub and the Roundtail Chub in the Colorado River System shows that neither species could be discriminated using mitochondrial DNA (mtDNA), although markers successfully separated both species from the Bonytail (Douglas and Douglas 2007). The recent coalescence of lineages is most parsimoniously explained by an historical scenario in which both species were reduced to very small populations by an end-of-Pleistocene warming and drying event (~12,000 years ago) that forced them together into shrinking riverine habitat. They then hybridized, possibly backcrossing (progeny to parental forms) over an extended time. Eventually, pluvial conditions returned, the aquatic environment expanded, and the species returned to familiar and exclusive niches in their natal rivers. The large-scale population reduction would have reset their mtDNA evolutionary clocks, and hybridization would have provided both species with the same haplotype(s). This evolutionary history shows that the Humpback Chub has survived large historical environmental changes and periods of extensive hybridization.

As a result of the microsatellite (msat) analysis, Douglas and Douglas (2007) designated the following genetic subgroups of *Gila* for the Colorado River System:

1. *G. elegans*;
2. All Grand Canyon *G. cypha* aggregations;
3. Desolation Canyon *G. cypha* and *G. robusta;*
4. Upper basin *G. cypha* (excluding *G. cypha* from Desolation Canyon);
5. Upper basin *G. robusta* (excluding *G. robusta* from Desolation Canyon and Yampa River); and
6. Upper basin *G. robusta* from the Yampa River.

Although intergrades of Humpback Chub, Roundtail Chub, and Bonytail suggest extensive hybridization with possible concomitant loss of genetic diversity and evolutionary adaptive traits (Rosenfeld and Wilkinson 1989), some scientists believe that introgressive hybridization is part of the evolutionary history of the Colorado River *Gila* that has resulted in high adaptability to the variable and rigorous conditions of the Colorado River System (Dowling and DeMarais 1993). This hypothesis is supported by evidence of intergrades prior to extensive human alteration in the basin (Miller 1946). Hybridization and introgression among the three sympatric mainstem *Gila* species is evident in each of the five upper basin populations, but it is unclear if hybridization is enhanced by human alteration and if it reduces or replaces contemporary numbers of genetically distinct Humpback Chub.

In a more recent, but preliminary, genetic evaluation of upper basin Humpback Chub with comparisons to Roundtail Chub and Bonytail, Bohn (2016) and Bohn and Wilson (2017) determined that upper basin Humpback Chub are as genetically diverse as Roundtail Chub, and that there is no need to supplement upper basin Humpback Chub with lower basin genetic diversity. They recommend establishing Humpback Chub broodstocks for the lower basin and upper basin according to the following management units:

- Black Rocks and Westwater Canyon;
- Desolation, Gray, and Cataract Canyons; and
- Lower Basin.

Bohn and Wilson (2017) concluded that genetic clusters within Humpback Chub may reflect spawning site fidelity, and if so, spawning sites should be identified and preserved to prevent loss of diversity. They determined that the Black Rocks population contains the highest level of hybridization, but that present introgression is not likely related to anthropogenic activities. They caution that wild levels of introgression could increase in the absence of adequate spawning habitat, and advise that studies should be conducted to identify physical characters that best reflect underlying genetic structure of upper basin *Gila* spp.

2.5 Listing Status, Recovery Planning, and Consultations

The following is a chronology of listing actions for the Humpback Chub:

- First included in the List of Endangered Species issued by the Office of Endangered Species on March 11, 1967 (32 FR 4001);
- Considered as “endangered” under provisions of the Endangered Species Conservation Act of 1969 (16 U.S.C. 668aa);
- Received protection as “endangered” under Section 4(c)(3) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*); and
- Included in the list of endangered and threatened species published in the Federal Register on January 4, 1974 (39 FR 1175).

The Humpback Chub is listed as "endangered" throughout its historical range in the states of Arizona, Colorado, Utah, and Wyoming in the List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 & 17.12); it is also listed in Mexico, although no specimens have been reported from that country (Miller 2005).

The following recovery plan and revisions have been developed for the Humpback Chub:

- Recovery Plan approved on August 22, 1979 (USFWS 1979);
- Revised Recovery Plan approved on September 19, 1990 (USFWS 1990); and
- Recovery Goals that amended and supplemented the 1990 revised plan were approved August 1, 2002 (USFWS 2002), but were withdrawn and declared of no force and effect by court order on January 18, 2006 (*Grand Canyon Trust et al., vs. Gale Norton et al.*, United States District Court for the District of Arizona, Order No. 04-CV-636-PHX-FJM).

Additional ESA-related actions for the Humpback Chub include:

- Critical habitat designated as six reaches totaling 610 kilometers (km) of the Colorado River System on March 21, 1994 (59 FR 13374), including 319 km in the upper basin and 291 km in the lower basin (Figure 5);
- There are no experimental (10[j]) populations for the species;
- There are no DPSs proposed or designated for the species, since it was listed prior to the 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments (DPS; 61 FR 4721); and
- There are no Safe Harbor Agreements for the species, and the Lower Colorado River Multispecies Conservation Plan is a Habitat Conservation Plan that includes the Humpback Chub[1].

The Humpback Chub has been included in numerous Final Environmental Impact Statements (FEIS) and ESA Section 7 consultations throughout the Colorado River System, including:

- Numerous water projects in the upper basin as part of the Upper Colorado River Endangered Fish Recovery Program,[2] including the:
  - 15-Mile Reach Programmatic Biological Opinion (PBO; USFWS 1999);
  - Yampa River Basin PBO (USFWS 2005a);
  - Gunnison River Basin PBO (USFWS 2009a); and

[1] see: (http://www.lcrmscp.gov/fish/humpback_chub.html)
[2] see: (http://www.coloradoriverrecovery.org/documents-publications/section-7-consultation/consultation-list.html)

  - Operation of Flaming Gorge Dam FEIS, Biological Opinion and Record of Decision (Bureau of Reclamation 2006).

- Actions in the lower basin prior to and as part of the Glen Canyon Dam Adaptive Management Program,[3] including the:
  - 1978 Final Biological Opinion on the Operation of Glen Canyon Dam (USFWS 1978);
  - 1995 Biological Opinion and 1996 FEIS and Record of Decision on the Operation of Glen Canyon Dam (Bureau of Reclamation 1996);
  - FEIS for Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead, Record of Decision and Biological Opinion (U.S. Department of the Interior 2007);
  - 2008 Final Biological Opinion for the Operation of Glen Canyon Dam, with conservation measures that include Fall Steady Experimental Flows (2008–2012), High-Flow Experiments Protocol, and Nonnative Fish Control Protocol (USFWS 2008);
  - 2009 Supplemental Opinion for the Operation of Glen Canyon Dam (USFWS 2009b);
  - 2010 Biological Opinion for the Operation of Glen Canyon Dam (USFWS 2010);
  - 2016 Long-Term Experimental and Management Plan (LTEMP) EIS for Operation of Glen Canyon Dam (U.S. Department of the Interior 2016), and
  - 2016 Biological Opinion for the Glen Canyon Dam Long-Term Experimental and Management Plan, Coconino County, Arizona (USFWS 2016b).
- Actions of the Lower Colorado River Multi-Species Conservation Program[4], specifically:
  - 2005 Biological and Conference Opinion on the Lower Colorado River Multi-Species Conservation Program (USFWS 2005b).

[3] see: http://www.gcdamp.gov/
[4] see: http://www.lcrmscp.gov/general_program.html

3.0 SPECIES NEEDS

3.1 Factors That Control Life History Stages

The following is a description of resource needs for each of the seven life stages of the Humpback Chub, as depicted by a conceptual model (Figure 6). Abiotic and biotic factors that control or regulate the transition of individuals from one life stage to the next are enumerated and were used to help identify needs of the species at each life stage.

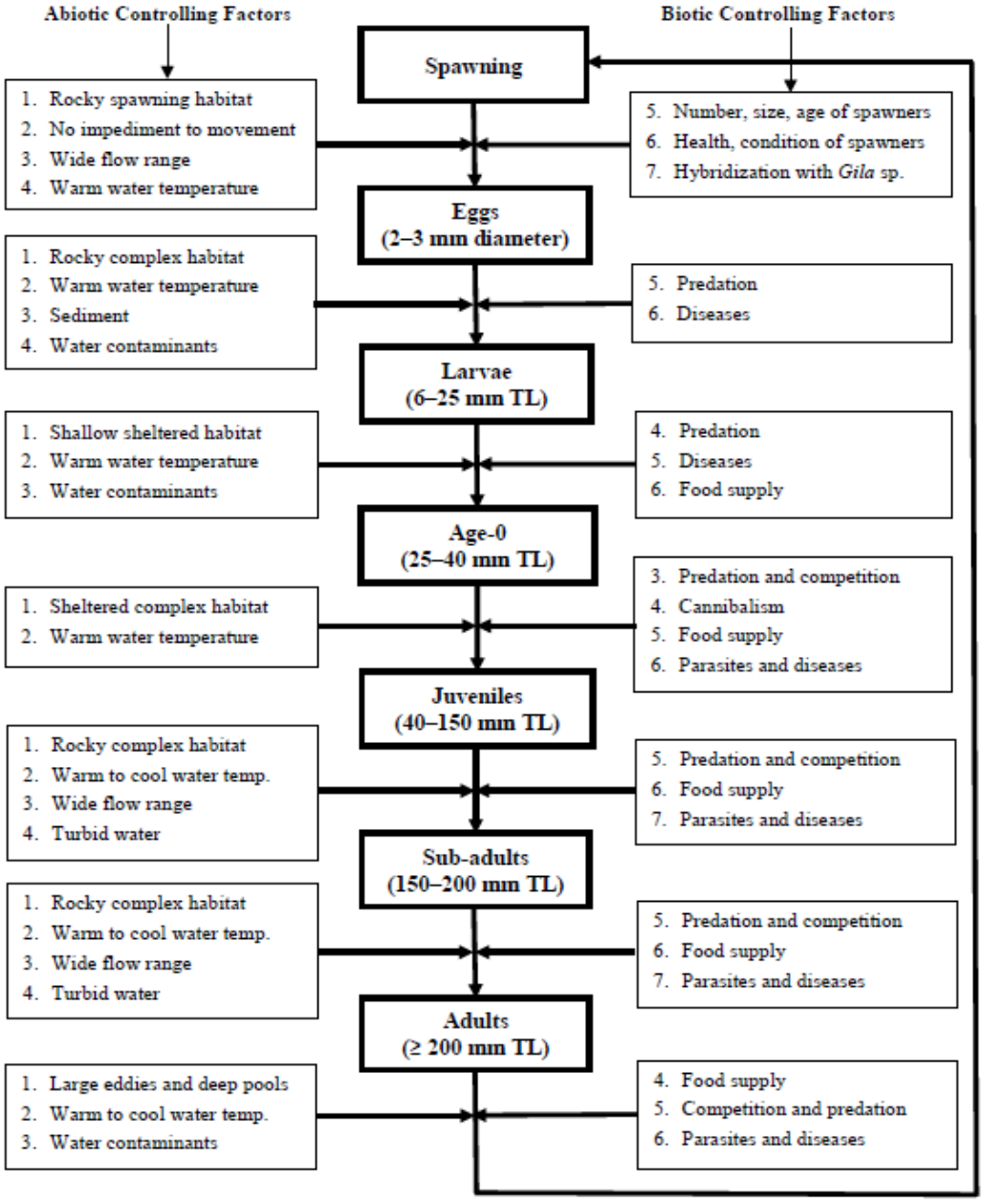


Figure 6. Life stages of the Humpback Chub with abiotic and biotic controlling factors.

3.1.1 Spawning—The Humpback Chub is a spring-time communal spawner that broadcasts and fertilizes its eggs on rocky substrates. Humpback Chub in the upper basin spawn in seasonally-warmed rivers and tributaries within population centers. In Grand Canyon, spawning likely occurred historically in the mainstem, but cold releases from Glen Canyon Dam starting in the late 1960s, have mostly precluded mainstem spawning, and the fish spawn primarily in the seasonally-warmed LCR. Spawning may have taken place historically in large tributaries, but reduced flows in the Paria River and Kanab Creek, and predators in Bright Angel Creek, Shinumo Creek, and Havasu Creek have rendered these tributaries largely inaccessible and unusable by the Humpback Chub.

The following identifies and describes the principal resource needs for spawning by factor:

1. **Rocky spawning habitat—**Spawning takes place in spring within the geographic boundaries of canyon-bound population centers usually along river margins and on mid-channel bars with boulder, cobble, and clean gravel substrate. In the upper basin, adults usually spawn in April–July, during or immediately after the peak of spring runoff and in the absence of detectable movement to specific locales (Valdez and Clemmer 1982; Kaeding et al. 1990); evidence of spawning in the Yampa River has been documented as late as September (Muth and Nesler 1993). In the Grand Canyon, adults spawn in March–April after moving short distances (< 15 km) from the cold Colorado River to the seasonally-warmed LCR (Valdez and Ryel 1995), where there is a subsequent ascent of up to 14 km (Douglas and Marsh 1996; Van Haverbeke et al. 2013). These spawning migrations to and from the LCR may be energetically costly and there is evidence of skipped-spawning, where some adults miss one or more years between spawning events (Yackulic et al. 2014; Pearson et al. 2015). There is also recent evident of mainstem spawning in western Grand Canyon (Rogowski et al. 2017).

2. **No impediment to movement—**There are no human-caused impediments to movement (e.g., waterfalls, dams, diversions) within or between the five upper basin populations. Fish passage has been installed on the Gunnison River and the upper Colorado River upstream of known populations that could allow the species to expand its distribution (see section 4.1.6). There is little movement of fish through the Grand Canyon (Paukert et al. 2006), although there is no impediment to movement in the mainstem (see section 4.2.6). An upstream barrier in the LCR is natural falls 14 km above the outflow, although passage by some marked fish is documented (Stone and Pillow 2015).

3-4. Wide flow range and warm water temperature—The Humpback Chub spawns at a wide range of flows and times in different populations, but at a rather narrow temperature range (Table 2). Suspected spawning in the upper basin has taken place from May 15 to September 6, and at a flow range of 65–60,000 cfs, but at a temperature range of only 15–24°C (Valdez and Clemmer 1982; Kaeding et al. 1990; Muth and Nesler 1993; Nelson et al. 2016). Although the species appears to spawn at a wide range of flow, inter-annual requirements are uncertain (e.g., flow change, spring peak).

Table 2. Dates, river flows, and water temperatures at which evidence of Humpback Chub spawning has been documented in the Colorado River System. Flow and temperature are from the nearest USGS gage for corresponding dates, unless otherwise indicated.

Population	Date	River Flow	Water Temperature	Reference
Black Rocks	June 2–15, 1980	21,500–26,000 cfs	18–20ºC	Valdez and Clemmer 1982
	May 15–25, 1981	3,000–5,000 cfs	17–19ºC	Valdez and Clemmer 1982
	June 20–July 30, 1983	14,000–60,000 cfs	15–20ºC	Kaeding et al. 1990
	June 25–July 31, 1984	10.500–42,000 cfs	17–22ºC	Kaeding et al. 1990
Cataract Canyon	June 15–23, 1988	41,500 cfs	20–23ºC	Valdez 1990
Yampa River (data for *Gila* spp. which included Humpback Chub)	June 17–August 24, 1980	5,600 cfs	18–20ºC	Muth and Nesler 1993
	June 6–August 22, 1981	2,400 cfs	16–24ºC	Muth and Nesler 1993
	June 17–September 5, 1982	6,000 cfs	15–21ºC	Muth and Nesler 1993
	June 18–September 6, 1983	7,000 cfs	No temperature data available	Muth and Nesler 1993
	June 12–August 23, 1984	9,700 cfs	No temperature data available	Muth and Nesler 1993
Little Colorado River	Commences mid-March to mid-April.	At high spring flows, spawning activity peaks as discharge approaches base flows (~230 cfs) in April	When mean water temperature rises above 14ºC, and preferably at 16–22ºC	Gorman and Stone 1999
	March and April 1981	No flow data available	18–20ºC	Kaeding and Zimmerman 1983
Colorado River in Grand Canyon (Fence Fault Spring, RM 30)	June 8, 1994; estimated from length of post-larvae.	12,000–19,000 cfs; mainstem flow.	16–19ºC; temperature in area of spring.	Valdez and Masslich 1999 Andersen et al. 2010
Colorado River in western Grand Canyon	April 29–July 24, 2015; estimated from fish length.	Mainstem flow range 9,000–18,000 cfs.	Mainstem temperature range 14–20ºC.	Kegerries et al. 2016
Havasu Creek	Unknown, age-0 fish captured in October.	Havasu base flows 65 cfs.	Timing of spawning unknown; ripe females and males found in May.	Nelson et al. 2016

In the Grand Canyon, spawning in the LCR takes place from mid-March to mid-April as discharge approaches base flow of 230 cfs and at a temperature of 16–22ºC (Kaeding and Zimmerman 1983; Gorman and Stone 1999). Evidence of spawning (i.e., post-larvae) was found in June in a riverside warm spring at 16–19ºC at mainstem flows of 12,000–19,000 cfs (Valdez and Masslich 1999; Andersen et al. 2010). Spawning has also been documented with translocated fish in Havasu Creek at an estimated flow of 65 cfs (Nelson et al. 2016). The occurrence of numerous young Humpback Chub in western Grand Canyon also indicates that mainstem spawning may be taking place in downstream reaches following warmer dam releases that started in 2004 (Rogowski et al. 2017). Lengths of larvae and age-0 fish indicate that spawning took place from April to July at a temperature of 14–20ºC and a flow of 9,000–18,000 cfs (Kegerries et al. 2016).

5. **Number, size, and age of spawners—**The five upper basin populations are each comprised of relatively few numbers of individuals that range from ~300 to over 1,600 adults; few individuals remain in the DNM population. The lower basin population in the Grand Canyon is comprised of over 12,000 adults in the mainstem and two tributaries, with recent expansions in numbers and distributions of fish. Fish in the upper basin are smaller than those in the Grand Canyon, and the females presumably produce fewer young. The longevity of fish in the upper basin is ~20 years, whereas fish in the Grand Canyon appear to reach ~40 years of age. The number, size, and age of adult spawners is important to the reproductive potential of individual populations, and management objectives strive to increase the size and age composition of each population (see also section 6.2).

6. **Health and condition of spawners—**The health and condition of adult Humpback Chub is not specifically monitored, other than a record of lengths and weights of fish captured during monitoring and research activities. The length to weight relationships showed differences in condition of fish from each population from information collected during the 1980s and 1990s (Meretsky et al. 2000), but a comprehensive assessment was not repeated. The present condition of Humpback Chub in Grand Canyon may be lower than previously reported in 2000, possibly because increased numbers of fish may be limiting space and food (Dzul et al. 2017). The health and condition of individual fish have not been associated with decline of any single population.

7. **Hybridization with *Gila* species—**As described in section 2.3, the Humpback Chub can hybridize with Roundtail Chub or Bonytail where the species co-exist. Incidence of hybridization appears to be higher during periods of drought when spring flows are reduced in magnitude and less arduous conditions allow for invasions of Roundtail Chub (Kaeding et al 1990; Chart and Lentsch 1999; Francis and McAda 2011). Periodic high spring flows can reduce the numbers of Roundtail Chub—and nonnative predators—in population centers. Although introgressive hybridization may be part of the evolutionary history of the species, the effect of hybridization on contemporary populations is not understood.

3.1.2 Eggs—The Humpback Chub broadcasts 1–2 mm diameter eggs on rocky substrate; the fertilized eggs swell to 2–3 mm and become semi-adhesive as they lodge in the crevices and interstitial spaces of the substrate. The following identifies and describes the principal resource needs for egg deposition and incubation by factor:

1-2. Rocky complex habitat and warm water temperature—The Humpback Chub in the upper basin broadcasts its eggs over rocky substrate comprised of boulder, cobble, and gravel (Valdez and Clemmer 1982; Kaeding et al. 1990). Females each release ~2,500 eggs into the water column (Hamman 1982) where they are fertilized as they settle into interstitial spaces where water circulation keeps the semi-adhesive eggs aerated. The fertilized eggs are 2–3 mm in diameter (Snyder et al. 2016) and incubate for 4–11 days at 16–22ºC (Hamman 1982). In the Grand Canyon, Humpback Chub spawn primarily in the LCR, where eggs are deposited on complex angular substrates of boulders and clean gravel at depths of 0.5–2 m, at 16–22ºC, and during the descending limb of spring runoff (Gorman and Stone 1999). Evidence of spawning has also been found in a warm spring (source temperature 21.5°C) near the river's rocky edge in Marble Canyon (Valdez and Masslich 1999) and in the rocky channel of Havasu Creek (Nelson et al. 2016).

3-4. Sediment and water contaminants—The Humpback Chub evolved in the muddy and turbid Colorado River and the extent to which high sediment accumulation at low flow affects egg incubation and survival is unknown. The fish tend to spawn in relatively moderate to high channel velocity where sediment accumulation is not expected to affect incubation. Presumably, the short incubation time (generally ~5 days) precludes much sediment deposition over the incubating eggs.

The effect of contaminants on Humpback Chub eggs has not been evaluated, although selenium and mercury have been identified as having physiological effects on Razorback Sucker and Colorado Pikeminnow (Waddell and May 1995; Osmundson et al. 2000).

5-6. Predators and diseases—Nonnative fishes, such as Common Carp, Red Shiner, and Fathead Minnow, prey on eggs and young of native fishes (e.g., Rupert et al. 1993), as do native Speckled Dace. The effect of this predation at the population level is not known, but is not believed to be significant because incubating Humpback Chub eggs are typically deep in interstitial spaces of substrates at relatively high velocity and inaccessible to most fish. Diseases are known to affect eggs in hatcheries, but have not been assessed in the wild.

3.1.3 Larvae—Humpback Chub larvae hatch in interstitial spaces of rocky substrate. The following identifies and describes the principal resource needs for the larvae by factor:

1-2. Shallow sheltered habitat and warm water temperature—Newly-hatched Humpback Chub larvae are 6–7 mm long (Muth 1990) and emerge (swim-up) from the interstitial spaces ~3 days after hatching (Hamman 1982). Survival of swim-up larvae in a hatchery occurred at 12–22ºC, but was optimal at 16–22ºC (Hamman 1982). There is little evidence of long-distance larval drift in upper basin populations, but the larvae are carried passively by currents to nearby sheltered shorelines consisting of boulders, cobble, and gravel (Valdez 1990). The five known populations in the upper basin are restricted to relatively small areas of river, and larvae have rarely been found downstream of these population centers (Valdez and Williams 1993).

The majority of larvae in the Grand Canyon are produced and remain in the lower 14 km of the LCR. Some larvae drift downstream from the LCR (Childs et al. 1998; Robinson et al. 1998) into the colder mainstem and likely die of thermal shock when mainstem temperatures are cold (Clarkson and Childs 2000). Transition checks on scales of age-0 fish indicate little or no survival of fish < 52 mm TL that drift from ~20ºC in the LCR to ~10ºC in the mainstem (Valdez and Ryel 1995). Hence, fish that egress from the LCR as larvae have lower survival than fish that leave at a larger size during or after the summer monsoon floods (Limburg et al. 2013). Warmer dam releases starting in 2004 have resulted in higher survival of young transitioning from the LCR to the mainstem (Dodrill et al. 2014).

Larvae and age-0 fish have been found in and downstream of warm springs in Marble Canyon (RM 30–61; Valdez and Masslich 1999; Andersen et al. 2010), and have also been found in the mainstem in western Grand Canyon. In May–September 2014 and 2015, 18 and 67 larval Humpback Chub, respectively, were caught in the mainstem Colorado River downstream of Lava Falls (RM 188–254) (Kegerries et al. 2016). Many of these fish were in the mesolarval and metalarval phases (8–12 days old), indicating that they originated from proximate locales and not the LCR, which is over 200 km upstream. The natal origin of these fish is unknown, but their young age and a lack of documented long-distance drift by the species is evidence that successful reproduction is taking place in the mainstem or tributaries of western Grand Canyon (Healy et al. 2014a; Nelson et al. 2016; Rogowski et al. 2017).

3. Water contaminants—There is a large suite of water contaminants in the Colorado River that may affect fish in various ways. Larval fish are susceptible to effects of contaminants because of contaminant accumulation through food organisms or waterborne exposure. Waddell and May (1995) determined that concentrations of selenium were highest in Razorback Sucker close to point sources associated with floodplains and drains; these areas are not in proximity of Humpback Chub populations and the effect of selenium is expected to be less. The effect of contaminants on Humpback Chub has not been investigated.

4-5. Predators and diseases—Larval Humpback Chub are small and vulnerable to predation by various fish species, including Common Carp, Red Shiner, Fathead

Minnow, and Speckled Dace. This type of predation exists, but the effect at the population level is not known. Notably, larval and post-larval Humpback Chub use very shallow habitat where photosynthetic production of food is high and access by larger predators is limited. Diseases of larval Humpback Chub in the wild have not been investigated.

6. **Food supply—**The early protolarval phase relies on a yolk sac for nutrition, but the yolk sac is completely absorbed and the mouth becomes functional in the late mesolarval phase at ~11 mm TL. Fin rays begin to develop in the post-flexion mesolarval phase and are fully developed in the metalarval phase before the fish transition to age-0 (Figure 7). Larvae and age-0 fish feed on diatoms, algae, and small invertebrates (e.g., rotifers, cladocerans, and copepods) present in shallow-water periphtyon communities.

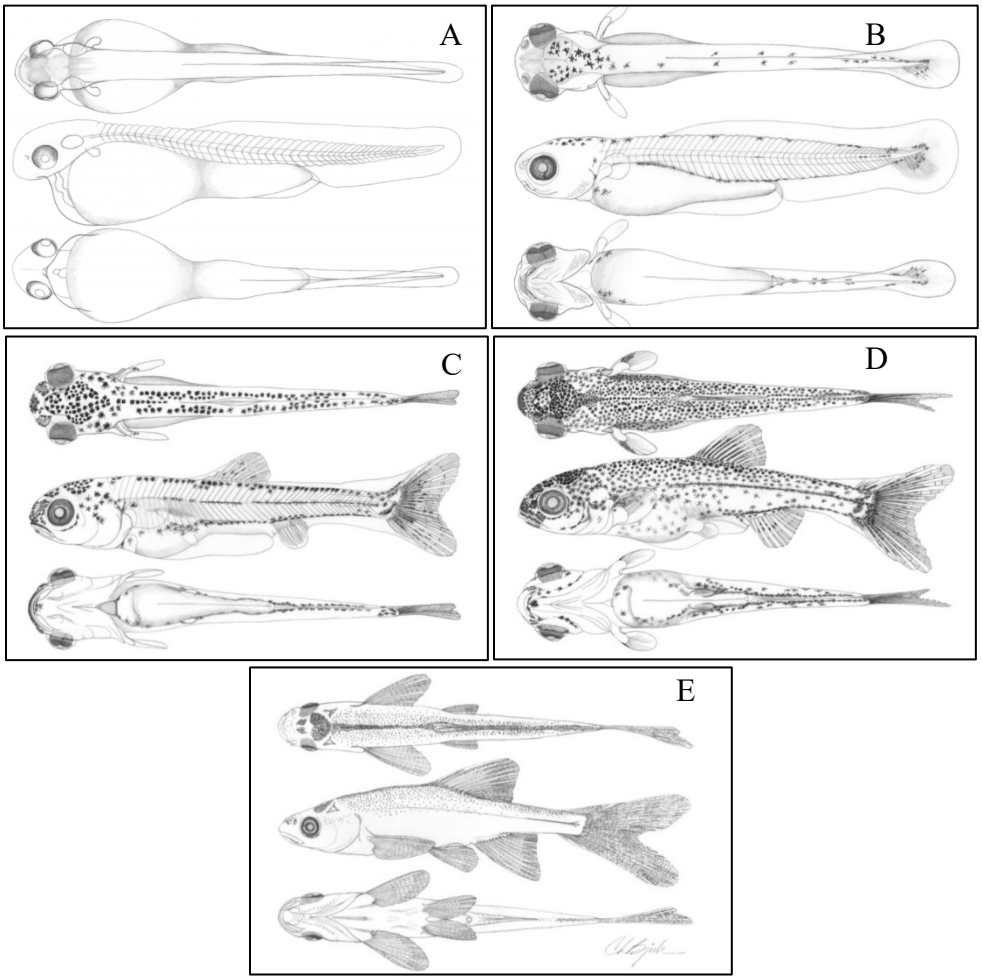


Figure 7. Illustrations of larval phases of Humpback Chub as (A) protolarva with yolk, (B) mesolarva with yolk, (C) postflexion mesolarva near transition to metalarva, (D) metalarva, and (E) juvenile life stages. Illustrations by C. Lynn Bjork from Snyder et al. (2016).

3.1.4 Age-0—Humpback Chub transform from the larval stage to age-0 at ~25 mm TL or 30–40 days of age, at which time they have fully developed fins and a functional mouth (Hamman 1982; Muth 1990). The following identifies and describes the principal resource needs for the age-0 fish by factor:

1-2. Sheltered complex habitat with warm water temperature—Age-0 Humpback Chub use rocky complex shorelines of boulders, talus, cobble, and vegetation where they hide in interstitial spaces during the day and emerge to feed under reduce light (Converse et al. 1998; Korman et al. 2004). Age-0 fish may also be found in sandy backwaters of the Grand Canyon, although this feature comprises a small portion of available habitat in canyon reaches (Ackerman 2008; Dodrill et al. 2014).

Age-0 Humpback Chub display measureable growth at a temperature of 12–24ºC, but optimal temperature for growth is 16–22ºC (Gorman and VanHoosen 2000). In the Grand Canyon, some age-0 fish remain and mature in the LCR, but most move, or are transported into the mainstem by monsoonal rainstorm floods at 3–4 months of age (Valdez and Ryel 1995). Most young fish in the Grand Canyon remain in the mainstem until maturity and subsequently return to the LCR for spawning (Douglas and Marsh 1996; Yackulic et al. 2014).

Otolith microchemistry of Humpback Chub from the LCR suggests a size advantage for fish that remain in the LCR for longer time periods in their first year of life; this size advantage may persist when the fish egress into the mainstem Colorado River (Limburg et al. 2013). Fish that egress from the LCR prior to the monsoon season have lower survival than fish that egress at a larger size during or after the high summer monsoon flows. For Humpback Chub, survival is thought to be strongly influenced by age and size, as acknowledged in a stock assessment framework developed for the species (Coggins et al. 2006).

Little is known about age-0 Humpback Chub in the upper basin, as these fish are difficult to sample and distinguish morphologically from the sympatric Roundtail Chub.

3-4. Predation and competition—Young Humpback Chub are susceptible to predation from sympatric piscivores because they lack spines and sharp scales. They may also be naïve to predators because of their evolutionary history in a river system with low fish diversity and small numbers of predatory fish. In the Grand Canyon, young Humpback Chub are particularly susceptible to predation by introduced Rainbow Trout and Brown Trout because of reduced swimming ability in the cold clear waters of the mainstem Colorado River (Valdez and Ryel 1995; Yard et al. 2011). Channel Catfish and Black Bullhead are predators in the LCR (Marsh and Douglas 1997), where adult and juvenile Humpback Chub are also cannibalistic under high densities of young (Gorman and Stone 1999). In upper basin populations, young Humpback Chub are particularly susceptible to predation from introduced Channel Catfish and Smallmouth Bass because of densities of these

large predatory fish in humpback chub habitats. Smallmouth Bass densities in Humpback Chub habitats are influenced by upstream areas of production; sympatric reproduction is uncommon, thus reducing densities in humpback chub habitats compared to other upper basin reaches.

5. **Food supply—**The diet of age-0 Humpback Chub is primarily diatoms, algae, and small invertebrates (e.g., rotifers, cladocerans, copepods) (Minckley 1997). The availability of these small food items at the proper time of year is essential for growth and survival of the young fish.

6. **Parasites and diseases**—A suite of parasites is known from Humpback Chub that may affect condition and survival of individuals (Flagg 1982; Hoffnagle et al. 2006), but no known outbreak has occurred that has dramatically affected an entire population. The Asian tapeworm (*Bothriocephalus acheilognathi*) and the parasitic copepod (*Lernaea cyprinacea*) are common warm-water parasites of the Humpback Chub that can lead to stress, risk of infection or secondary disease, and possibly death of individual fish. In the Grand Canyon, the Asian tapeworm is most likely contracted by fish in the LCR where they consume a warm-water cyclopoid copepod that is host to the early life stage of the parasite (Valdez and Ryel 1995). Similarly, the parasitic copepod, *Lernaea*, is most likely contracted in warm quiet waters that contain the free-swimming early stages of the parasite. Since both parasites need ~20ºC temperature to mature and reproduce, infections generally occur in warm river reaches and tributaries.

3.1.5 Juveniles—Age-0 Humpback Chub transition into the juvenile stage at 1 year of life, or at ~40 mm TL, and they become sub-adults or recruits at ~150 mm TL. The following identifies and describes the principal resource needs for juveniles by factor:

1. **Rocky complex habitat—**Juveniles in the upper basin use rocky complex habitat, often along shorelines, and they move to increasingly deeper offshore areas of large boulders and cobble with increasing size and age (Karp and Tyus 1990; Valdez et al. 1990; Chart and Lentsch 1999). Juveniles in the Colorado River in Grand Canyon use rocky talus shorelines where they move up-slope and down-slope to maintain position with depth and velocity under changing water levels from dam operations (Converse et al. 1998; Trammell et al. 2002; Korman et al. 2004). Juveniles in the mainstem may also use backwaters, but this habitat feature is rare, ephemeral, and usually contains a small portion of the overall number of juveniles in the system (Dodrill et al. 2014). Habitat of juveniles in the LCR is deep mid-channel pools and chutes with large boulders and cobble (Stone and Gorman 2006).

2. **Warm to cool water temperature—**Temperature is an important factor in the growth and survival of juvenile Humpback Chub. Juveniles grow and survive well at 17–27ºC (Bulkley et al. 1982), which is within the range of summer temperatures in the upper basin and the seasonally-warmed LCR. Temperature in the mainstem Colorado River

through Grand Canyon is usually colder, which results in slower growth than in the LCR (Robinson and Childs 2001). Generally, water temperature of ~12–27ºC is suitable for growth, with an optimal range of 16–22ºC (Gorman and VanHoosen 2000).

Although the Humpback Chub is a warm-adapted species, there appear to be benefits to later life stages from cooler temperature. Growth in the cooler Colorado River in Grand Canyon is slower than in the LCR, but individuals in the mainstem live longer (Yackulic et al. 2014), have better body condition (Meretsky et al. 2000), and carry fewer parasites (Hoffnagle et al. 2006). Cooler mainstem temperature limits development and reproduction of the Asian tapeworm and the parasitic copepod, *Lernaea*, which are common warm-water parasites of the Humpback Chub (Hoffnagle et al. 2006).

3. **Wide flow range—**Juvenile Humpback Chub have a demonstrated ability to live in a wide range of flows. In places like Cataract Canyon, the species has persisted despite experiencing annual flow range of 3,000 to 100,000 cfs (Valdez 1990). In the Grand Canyon, juveniles have a demonstrated ability to remain at suitable depth and velocity by adjusting position along rocky talus shorelines during dam releases of 5,000 to 25,000 cfs (Converse et al. 1998; Korman et al. 2004). During September and October of 2008–2012, dam releases were kept relatively steady within a range of 8,000–15,500 cfs; juvenile survival of 37–67% was not significantly different for approximately steady vs fluctuating flows (Finch 2012). Growth and survival of juveniles were higher but not significant under fluctuating flows, and relatively steady flow did not improve either. These studies suggest that growth and survival of juvenile Humpback Chub are robust to a wide range of contemporary flows.

4. **Turbid water—**Juvenile Humpback Chub are most active during mornings and evenings under low light conditions, and during flooding when turbidity is high (Valdez and Ryel 1995); the fish evidently use turbidity for safe movement and cover from predators. Given that the Colorado River is historically turbid, increased activity in turbidity is an apparent evolutionary adaptation for cover from predators (Ward and Morton-Starner 2015) and for increased food availability delivered by floods (Valdez and Hoffnagle 1999).

5. **Predation and competition—**As with age-0 fish, juvenile Humpback Chub are susceptible to predation because they lack spines and sharp scales and may be naïve to predators. In the Grand Canyon, juvenile Humpback Chub are susceptible to predation and competition by Rainbow Trout and Brown Trout (Valdez and Ryel 1995; Yard et al. 2011). The species is also highly susceptible to predation in the confined environment of the LCR (Marsh and Douglas 1997), where a school of large predators, such as Channel Catfish or Striped Bass, could move into the tributary and consume a large number of Humpback Chub. In upper basin populations, juvenile Humpback Chub are susceptible to predation from introduced Channel Catfish and Smallmouth Bass. Smallmouth Bass

densities in Humpback Chub habitats are influenced by upstream areas of production; Humpback Chub habitats do not support large densities of reproducing Smallmouth Bass.

6. **Food supply—**Juvenile Humpback Chub consume a variety of foods, including aquatic insects (e.g., black flies and midges) and crustaceans, as well as terrestrial insects when available (e.g., grasshoppers, Mormon crickets) (Jacobi and Jacobi 1982; Tyus and Minckley 1988; Valdez and Ryel 1995). These food resources resemble historic conditions in the upper basin, but have been altered in composition and abundance by cold and varying dam releases in the Grand Canyon.

7. **Parasites and diseases**—Juvenile Humpback Chub that carry the Asian tapeworm or the parasitic copepod, *Lernaea*, probably contracted these warm-water parasites in the LCR or another warm tributary or area in the Grand Canyon. Although water temperature in the mainstem is generally < 20°C, these parasites survive but cannot reproduce, unless the fish accesses a warm area, such as the LCR.

3.1.6 Sub-adults—Resource needs are not described specifically for sub-adults because of their overlap with those of juveniles and adults. Nevertheless, sub-adults are distinguished from juveniles in this assessment because they constitute the fish that are recruits, or those individuals that will mature to reproductive adults in the next 1–2 years of life, and because their needs differ somewhat between basins. In the upper basin, there is little difference between juveniles and sub-adults, except for a transition in habitat to deeper water with size and age. Juveniles reach the sub-adult stage at ~150 mm TL, or 2–3 years of age.

The timing and age for Humpback Chub development are largely temperature dependent, with fish in warm habitats reaching maturity in 3–4 years, whereas fish in the colder Colorado River in Grand Canyon may require 8–15 years to reach maturity (Coggins and Pine 2010; Yackulic et al. 2014). In the lower basin, the transition to sub-adults and adults is confounded by differences in water temperature between the seasonally-warmed LCR and the colder mainstem (Coggins and Pine 2010). Life-long residents of the LCR grow quickly to adulthood and have shorter life expectancies; whereas, fish that hatch in the LCR and transition to the mainstem as juveniles, grow much slower and require longer to become sub-adults. Sub-adults that rear in the mainstem take more than twice as long to reach adulthood and are ~40% less likely to survive to adulthood; however, these fish live much longer, on average, than adults reared in the LCR (Yackulic et al. 2014).

3.1.7 Adults—Adult Humpback Chub use deep pools and large eddies and they consume a variety of foods. The following identifies and describes the principal resource needs for adults by factor:

1. **Large eddies and deep pools—**Adults in the upper basin use primarily offshore habitats, including large eddies and deep pools, but they move to feed in shallow complex

shoreline habitats at night or during periods of high turbidity (Valdez 1990; Chart and Lentsch 1999). Adults in the Grand Canyon use primarily large recirculating eddies and deep pools where they feed on entrained foods carried by the river, but they also feed along shorelines at night and at times of moderate to high turbidity (Valdez and Ryel 1995). Adults may move daily within large recirculating eddy complexes (Gerig et al. 2014). Adults in the LCR and those translocated to other tributaries (Shinumo and Havasu creeks) also use the deepest pools available (Healy et al. 2014a; Nelson et al. 2016).

2. **Warm to cool water temperature—**The Humpback Chub is a warm-water species, and age and size at maturity are largely temperature-dependent, but may also vary with population. Male Humpback Chub in the upper basin and in the seasonally-warmed LCR generally mature at 3–4 years of age, and females generally mature at 4–5 years of age (Hamman 1982; Valdez and Ryel 1995). Fish that inhabit the colder mainstem in Grand Canyon may take 8–15 years to mature (Yackulic et al. 2014).

   Like juveniles and sub-adults, the adults in the colder mainstem in Grand Canyon are in generally better condition (Meretsky et al. 2000), have fewer parasites (Hoffnagle et al. 2006), and live longer (Yackulic et al. 2014) than adults in the seasonally-warmed LCR. Measureable growth of adults occurs at 12–27ºC, but is optimal at 16–22ºC. The species is able to live year-round in cooler water of 12–18ºC with slower growth but greater longevity and higher survival, as seen in the Colorado River in Grand Canyon.

   The longevity of the Humpback Chub also appears to be temperature-dependent. Adults that spend most of their time in the colder mainstem in the Grand Canyon appear to live up to 40 years, based on tag recaptures and growth rates (Coggins et al. 2006); whereas fish that spend most of their time in the seasonally-warmed LCR and fish in the upper basin live ~20 years. An examination of captured and recaptured Humpback Chub in the upper basin from the STReaMS database revealed a maximum of 16 years between initial capture of a fish 246 mm TL in 1994, and 392 mm TL at last capture in 2010. This fish was likely 4–6 of age at initial capture (based on length-age relationship) and was therefore 20–22 years of age at recapture (STReaMS, July, 2016).

3. **Water contaminants—**The Colorado River contains a large suite of municipal, agricultural, and industrial pollutants (including mining wastes and airborne chemicals) that potentially directly or indirectly affect many aspects of the species' life history. Loss of Humpback Chub to stochastic events, such as oil spills, large ash flows, and debris flows, are documented, but the possible insidious effects of low-levels of various elements or chemicals, such as mercury, selenium, or various petroleum compounds, have not been investigated and are largely unknown.

4. **Food supply—**Adult Humpback Chub feed actively on floating material entrained in eddies and low-velocity areas during floods and high fluctuating flows. The fish feed on

aquatic insects, crustaceans, plants, seeds, and occasionally small fish, as well as terrestrial insects and reptiles (Valdez and Ryel 1995). High flows are often food-laden and turbid and individuals appear to use turbidity as cover from predators and competitors. The fish feed extensively on sporadic food supplies brought on by large flow events, as observed during an artificial flood in the Grand Canyon (Valdez and Hoffnagle 1999), and with seasonal phenomena such as grasshopper infestations or Mormon cricket emergences and migrations (Tyus and Minckley 1988). In Grand Canyon, the availability and timing of food in the LCR may dictate when fish move to the mainstem; i.e., food availability in the LCR is highest in April and May, but lower in summer, fall, and winter, limiting carrying capacity and likely forcing or facilitating fish to move to the mainstem with monsoonal floods.

5. **Competition and predation**—Adult Humpback Chub are usually too large for most predators that inhabit the Colorado River to consume, except for an occasional large Channel Catfish, Northern Pike, or Striped Bass (the latter two of which are rare in Humpback Chub habitats). Competition for food and space, however, is possible with a number of species, especially introduced nonnative fishes, such as Smallmouth Bass, Walleye, Largemouth Bass, and Green Sunfish in the warm-water regions of the upper basin. However, densities of these species are either low, or variable to environmental conditions, demonstrating habitats occupied by Humpback Chub are not conducive to establishment of large populations of these nonnative fish. Spurgeon et al. (2014) determined that Humpback Chub and introduced Rainbow Trout in the Grand Canyon use similar food resources high in the food web, suggesting that the two species occupy a similar energetic niche following the changes brought about by Glen Canyon Dam. Competition from native Roundtail Chub is also possible where the species are sympatric in upper basin populations.

6. **Parasites and diseases**—Like juvenile Humpback Chub, adults that carry the Asian tapeworm or the parasitic copepod, *Lernaea*, probably contracted these warm-water parasites in the LCR or another warm tributary or area in the Grand Canyon. Although water temperature in the mainstem is generally < 20ºC, these parasites survive but cannot reproduce, unless the fish access a warm area, such as the LCR.

3.2 Species Needs Categories

The needs of the Humpback Chub are drawn from the life history description in section 3.1. A summary of life stages, species needs, and information sources (i.e., references) is provided in Table 3. These species needs are grouped into the following eight categories as necessary aspects of the environment of the species (Figure 8). These species needs categories become the basis for describing current and future condition for the Humpback Chub in this status assessment. Photographs of habitats that illustrate some of these resources are shown in Figures 9–10.

1. Diverse rocky canyon river habitat
    a. Spawning: rocky substrate of boulder, cobble, and clean gravel, usually along river margins and on mid-channel bars.
    b. Eggs: complex habitats with rocky substrate of boulder, cobble, and gravel with clean interstitial spaces.
    c. Larvae: shallow sheltered habitat with boulders, cobble, and gravel with clean interstitial spaces.
    d. Age-0: shallow shorelines of boulders, cobble, talus, and vegetation.
    e. Juveniles and sub-adults: deep sheltered shorelines of boulders, cobble, talus, and vegetation.
    f. Adults: deep shorelines and offshore habitats, including large recirculating eddies and pools.
2. Suitable river flow and temperature
    a. Spawning: water temperature of 16–22ºC; wide flow range near spring runoff.
    b. Eggs: water temperature of 16–22ºC; optimal 21–22ºC; wide flow range.
    c. Larvae: water temperature of 12–22ºC; optimal 16–22ºC; susceptible to cold shock; wide flow range.
    d. Age-0: water temperature for growth, 12–24ºC; optimal 16–22ºC.
    e. Juveniles and Sub-adults: water temperature for growth, 12–27ºC; optimal 16–22ºC.
    f. Adults: water temperature for growth, 12–27ºC, optimal 16–22ºC; cooler water of 12–18ºC results in slower growth but greater longevity.
3. Adequate and reliable food supply
    a. Larvae: begin feeding at mesolarval and metalarval phases on diatoms, algae, and small invertebrates (e.g., rotifers, cladocerans, and copepods).
    b. Age-0: small food items such diatoms, algae, and small invertebrates (e.g., rotifers, cladocerans, copepods), and aquatic insects (midges and blackflies).
    c. Juveniles, sub-adults, and adults: a variety of foods, including aquatic insects (midges and blackflies), crustaceans, plants, seeds, and terrestrial insects and reptiles delivered by flood events; adults eat fish and may cannibalize young.
4. Habitat with few nonnative predators and competitors
    a. A fish community with few or no nonnative predators or competitors that is compatible with a viable reproducing population of Humpback Chub.
    b. Rocky or vegetated cover and water turbidity for safe movement and cover from predators during feeding.
5. Suitable water quality
    a. Water free of contaminants, or with low levels that do not produce detrimental effects to individuals.

   b. Security from spills of petroleum products and other toxic materials.

6. Unimpeded range and connectivity
   a. Free movement of fish with no impediments to access habitats necessary for all life stages.
   b. Suitable habitat and a full range of conditions necessary for life stages.
7. Persistent populations
   a. Sufficient numbers of independent reproducing groups of fish to ensure redundancy and resiliency.
   b. Adequate numbers of individuals in each population to ensure reproductive potential, recruitment, and long-term persistence.
8. High genetic diversity
   a. High genetic diversity within and across populations to ensure adaptive traits.
   b. Minimization of introgressive hybridization with other *Gila* species.

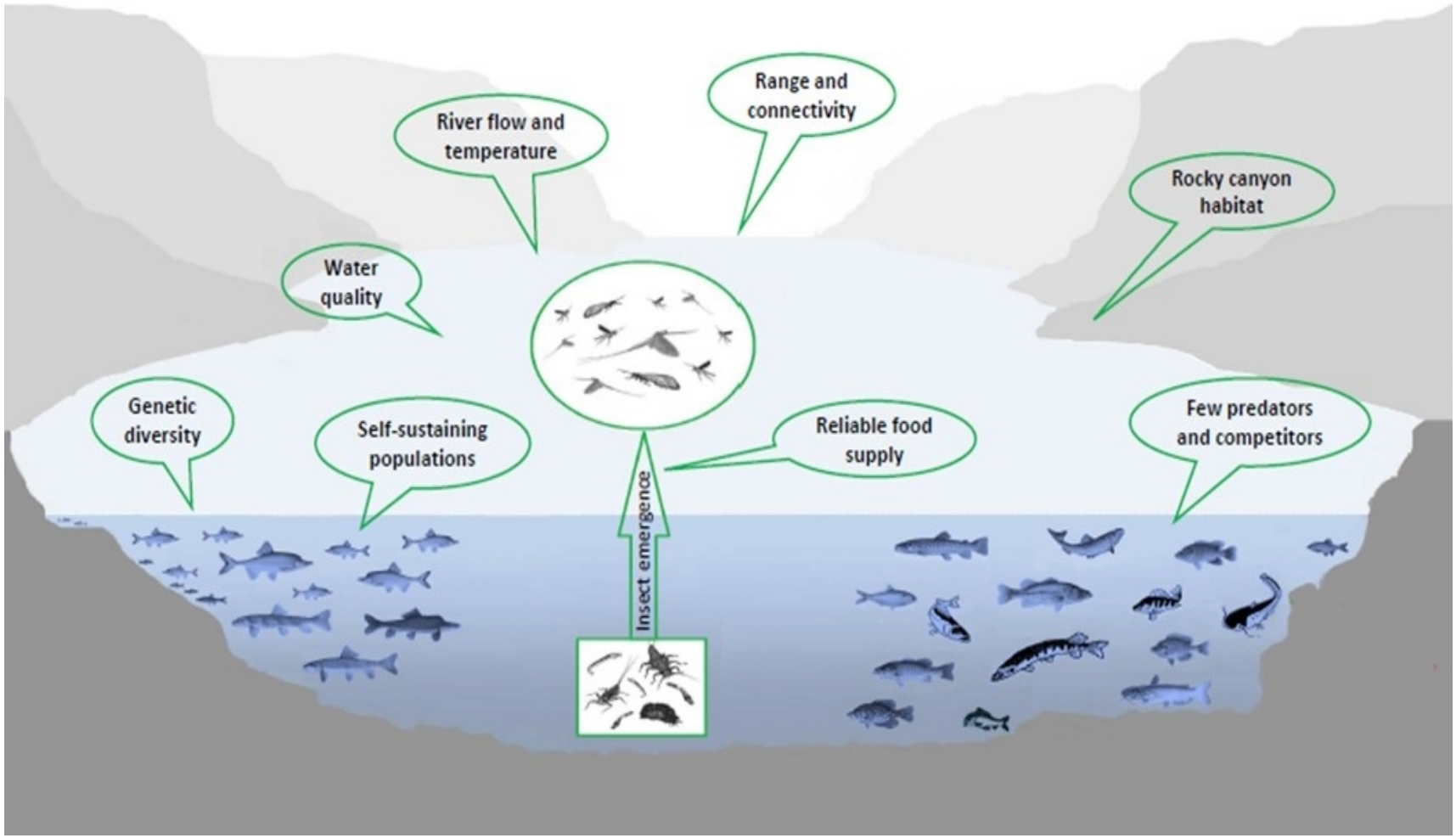


Figure 8. Species needs categories for the Humpback Chub.

Table 3. Summary of species needs for the Humpback Chub by life stage and references for information.

Life Stage	Species Need	Reference
Spawning	• Rocky substrates of boulder, cobble, talus and gravel, usually along river margins and on mid-channel bars, 0.5–2.0 m deep. • Water temperatures of 16–22ºC; wide flow range of 65–60,000 cfs.	• Kaeding et al. 1990 • Valdez and Clemmer 1982 • Gorman and Stone 1999
Eggs (1–2 mm diameter when deposited; 2–3 mm when fertilized)	• Complex habitats with rocky substrates of boulder, cobble, and clean gravel • Semi-adhesive eggs are deposited at depths of 0.5–2 m. • Water temperature of 16–22ºC, optimal 21–22ºC. • Habitat with few nonnative predators and competitors that may limit egg survival.	• Hamman 1982 • Valdez and Clemmer 1982 • Kaeding et al. 1990 • Gorman and Stone 1999
Larvae (6–25 mm TL)	• Clean, silt-free gravel for shelter after hatching . • Shallow shorelines with boulders, cobble, and gravel. • Warm currents for short-range drift, 12–22ºC, optimal 16–22ºC; susceptible to cold shock. • At mesolarval and metalarval phases, feed on diatoms, algae, and small invertebrates. • Habitat with few nonnative predators and competitors that may limit larval survival.	• Muth 1990 • Valdez 1990 • Childs et al. 1998 • Clarkson and Childs 2000
Age-0 (25–40 mm TL)	• Shallow shorelines of boulders, cobble, talus, backwaters, or vegetation. • Warm waters for growth, 12–24ºC, optimal 16–22ºC. • Small food items such diatoms, algae, and small invertebrates (e.g., rotifers, copepods). • Habitat with few nonnative predators and competitors that that may limit age-0 survival.	• Converse et al. 1998 • Gorman and VanHoosen 2000 • Korman et al. 2004 • Dodrill et al. 2014
Juveniles (40–150 mm TL)	• Complex shoreline habitats with large boulders and cobble. • Turbid water for safe movement and cover from predators during feeding. • Warm waters for growth, 12–27ºC, optimal 16–22ºC. • A variety of foods, including aquatic insects (black flies and midges) and crustaceans. • Habitat with few nonnative predators and competitors that may limit juvenile survival.	• Converse et al. 1998 • Bulkley et al. 1982 • Gorman and VanHoosen 2000 • Kennedy et al. 2013 • Dodrill et al. 2014
Sub-adults (150–200 mm TL)	• Complex shoreline habitats, with larger fish using increasingly deeper offshore habitats with large boulders and cobble. • Turbid water for safe movement and cover from predators during feeding. • Warm waters for growth, 12–27ºC, optimal 16–22ºC. • A variety of foods, including aquatic insects (black flies and midges) and crustaceans. • Habitat with few nonnative predators and competitors that may limit sub-adult survival.	• Bulkley et al. 1982 • Valdez and Ryel 1995 • Gorman and VanHoosen 2000 Kennedy et al. 2013 • Dodrill et al. 2014 • Yard et al. 2011
Adults (≥ 200 mm TL)	• Offshore habitats of greater depth, including large eddies, deep pools. • Turbid water for safe movement and cover from predators during feeding. • Warm waters for growth, 12–27ºC, optimal 16–22ºC, cooler waters for longer survival, 10–18ºC. • A variety of foods, including aquatic insects, crustaceans, plants, seeds, and occasionally small fish; as well as terrestrial insects and reptiles delivered by flood events. • Habitat with few nonnative predators and competitors that may limit adult survival. • Periodic high spring flows to reduce incidence of hybridization with sympatric *Gila.*	• Hamman 1982 • Valdez and Ryel 1995 • Kennedy et al. 2013 • Dzul et al. 2017 • Yackulic et al. 2014 • Dodrill et al. 2014 • Chart and Lentsch 1999

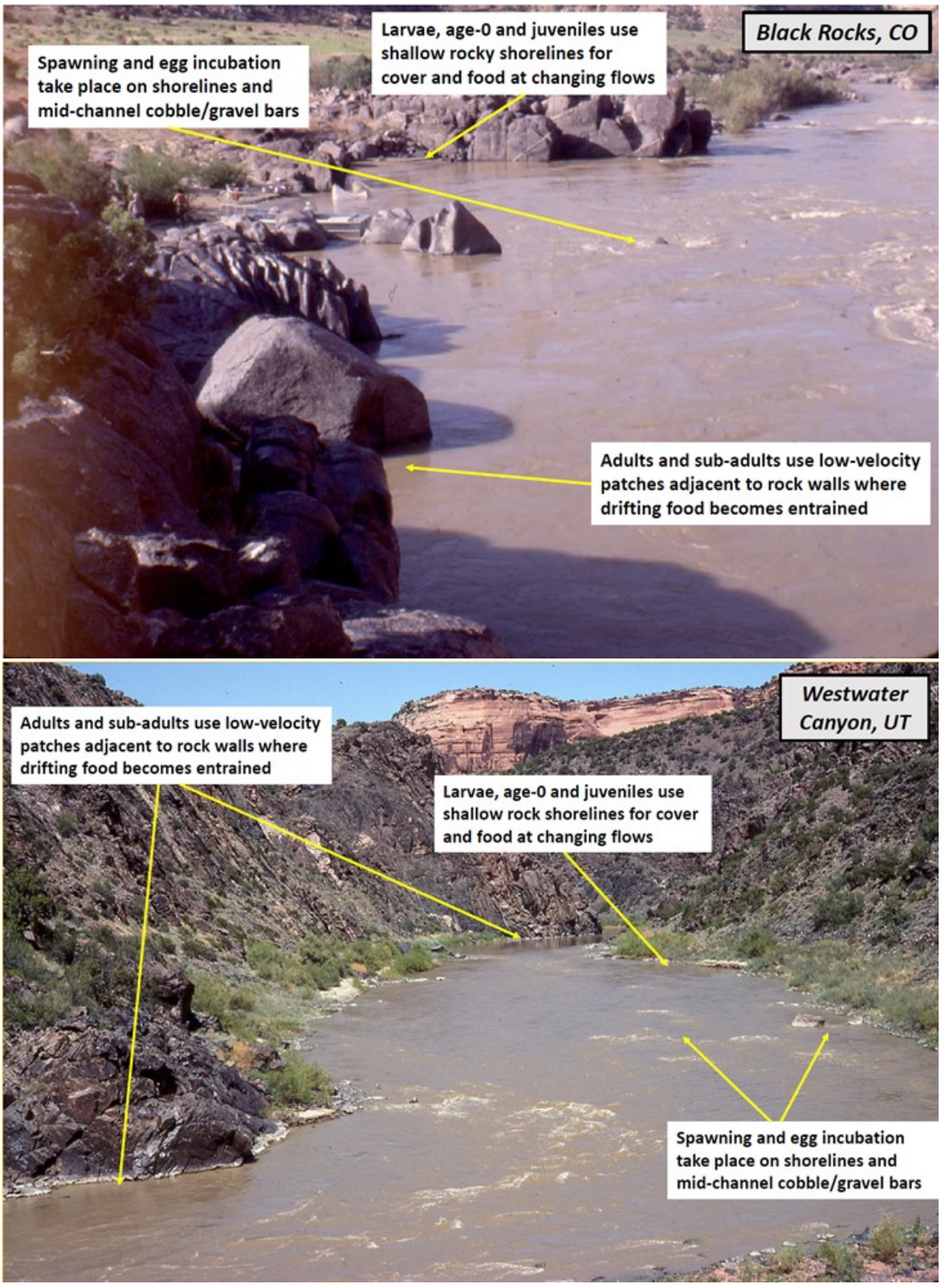


Figure 9. Life history needs of the Humpback Chub in Black Rocks, CO (top), and Westwater Canyon, UT (bottom), of the upper Colorado River basin.

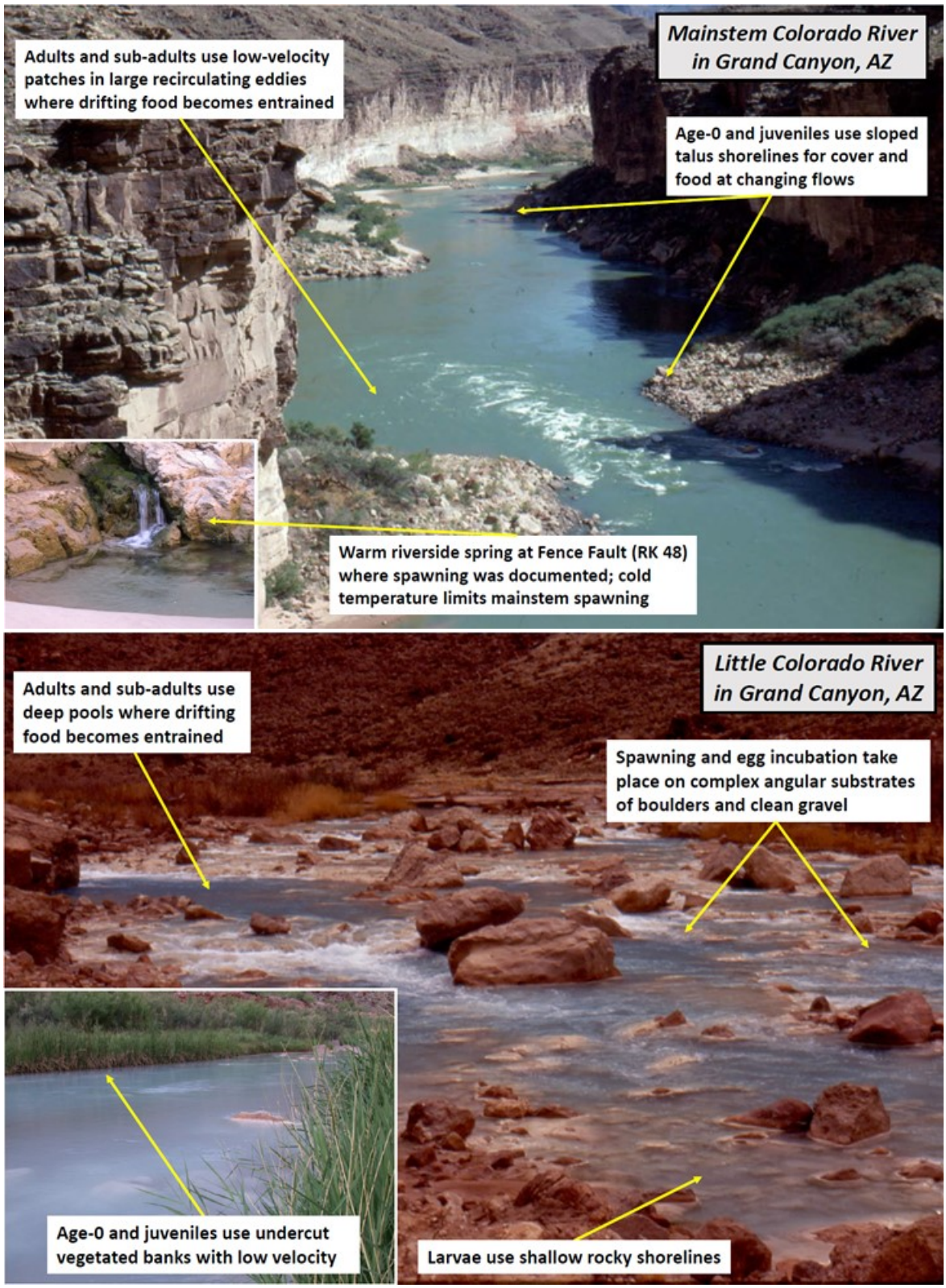


Figure 10. Life history needs of the Humpback Chub in the mainstem Colorado River (top) and the Little Colorado River (bottom) in Grand Canyon, AZ.

4.0 CURRENT CONDITION

This section describes the current condition of the Humpback Chub's habitat and demographics, and the probable explanations for past and ongoing changes in abundance and distribution within the species' ecological settings. First, current conditions of the species' resource needs are described by species needs category (as outlined in section 3.2). Sections 4.1 and 4.2 provide detailed descriptions of the current condition of these categories in the upper basin and lower basin, respectively. Section 4.3 then provides a summary of the current condition of these categories in each of the six Humpback Chub populations. Section 4.4 describes the ongoing conservation and management actions that influence the current condition of specific resources needs. Finally, section 4.5 describes the most up-to-date population monitoring data for the six populations, demonstrating population size and trajectory.

4.1 Upper Basin Current Resource Conditions

4.1.1 Diverse Rocky Canyon River Habitat—The following is a summary of rocky canyon habitat in populations of the upper basin followed by a detailed description:

- Rocky canyon habitat is largely unchanged and located in lands administered by federal, state, and tribal agencies that protect the current condition;
- The only major change to historical canyon habitat is inundation by reservoirs formed by large mainstem dams in the 1960s;
- Altered flow regimes have modified sediment budgets and allowed shorelines to be invaded by nonnative vegetation, but with minimal effect to canyon areas; and
- Riverine habitat is expanding in Cataract Canyon, as Lake Powell has receded since 2002 and the river continues to erode lake sediment and expose the historical river channel.

The Humpback Chub in the upper basin inhabits canyon-bound reaches with steep gradients, rapids, and coarse substrates. The river channels are comprised of hard rock substrate largely unchanged by human activity or contemporary river flow (Figure 11). All five populations inhabit roadless areas that are largely inaccessible and free of direct human alteration. The canyons and surrounding areas of upper basin populations are located in or adjacent to lands administered by the Bureau of Land Management (Black Rocks, Westwater Canyon, and Desolation/Gray canyons), the National Park Service (DNM and Cataract Canyon), and the Uintah and Ouray Indian Reservation (Desolation/Gray canyons). These canyon areas are popular whitewater boating and recreational areas, and they are protected by the rules and regulations of the appropriate agency.

Although there are no changes to the geomorphology of these canyon areas, altered flow regimes in the upper basin have modified sediment budgets, and reduced spring peaks have

allowed shorelines to be invaded by nonnative tamarisk and Russian olive, but with minimal effect on canyon habitats. The only major change to historical habitat is inundation by reservoirs formed by large mainstem dams in the 1960s; one population was extirpated (Flaming Gorge/Hideout Canyon) and one was reduced in distribution (Cataract Canyon). Recent low levels of Lake Powell have exposed the historical habitat in lower Cataract Canyon that could allow for downstream expansion of the Cataract Canyon population.



Figure 11. Rocky canyon habitat occupied by Humpback Chub in Black Rocks, Westwater Canyon, Desolation/Gray canyons, and Cataract Canyon of the upper Colorado River basin.

4.1.2 Suitable River Flow and Temperature—The following is a summary of flow and temperature conditions in populations of the upper basin followed by a detailed description:

- Flow regimes have been altered for more than 75 years, most significantly in the last 50 years by flow regulation and water withdrawal, brought about by construction of mainstem storage projects and irrigation diversions in the mainstem and tributaries;
- Invasions of nonnative fishes and hybridizing Roundtail Chub into populations are correlated with reduced spring flow;
- Temperature of upper basin rivers have increased over the last 40–65 years as a result of lower stream flow, increased air temperature, and higher evaporation attributed to drought and possibly reduced snowpack;

- Persistence of populations is evidence that the species is able to complete its life history at the range of flows and temperatures currently seen in the upper basin, but relationships to life stages remain largely unquantified; and
- Written and reviewed flow and temperature recommendations help to identify and evaluate species needs. The Upper Colorado River Endangered Fish Recovery Program (UCRRP) stakeholders have made great strides in the past 15 years to implement flow and temperature recommendations and have restored important aspects of intra- and inter-annual flow variability necessary to support Humpback Chub populations.

Flow—The flow regimes of rivers in the upper basin have been altered in the last 50 years by flow regulation and water withdrawal, brought about primarily by construction of mainstem dams in the 1960s. There has been little additional flow reduction in recent years, but periods of drought have produced periods of low flow. For those areas occupied by the Humpback Chub, spring peaks (June) have been reduced and summer and winter base flows (January) have increased, as described below for the periods ending with 1961 (pre-dam era) and starting in 1962 (post-dam era) (Figure 12):

- upper Colorado River: spring peak decreased by 33% and base increased by 37%;
- Green River: spring peak decreased by 34% and base increased by 76%; and
- Yampa River: spring peak decreased by 4% and base increased by 5%.

The stream gages reflect flows for the various populations, including: (1) Colorado River near Cisco for Black Rocks and Westwater Canyon; (2) Green River at Green River for Desolation/Gray canyons; and (3) Yampa River near Maybell for Dinosaur National Monument (Yampa Canyon). Cataract Canyon is located downstream of the confluence of the Colorado and Green rivers, and receives a combination of flows and temperatures of the two rivers. There are no mainstem dams on the Yampa River and the flow regime has not changed appreciably, except for small reductions in base flow from tributary impoundments and local irrigation.

Relatively few studies (Chart and Lentsch 1999; Day et al. 2000) have been conducted on the relationship between river flow and various life stages of the Humpback Chub in the upper basin. The deep and relatively inaccessible canyons occupied by the species are difficult to sample, and the only linkages between flow and fish population dynamics are inferential and reflected in short-term adult numbers. As described in section 3.1.1, evidence of spawning in the upper basin has been reported at a wide flow range of 65–60,000 cfs, but the larvae, age-0, and juveniles are difficult to sample and identify, and the influence of flow on these life stages is not fully understood. It is believed that flows that benefit other native fishes also benefit the Humpback Chub (Muth et al. 2000). The persistence of populations in the upper basin is evidence that the species is able to complete its life history under the range of flows currently seen in the upper basin.

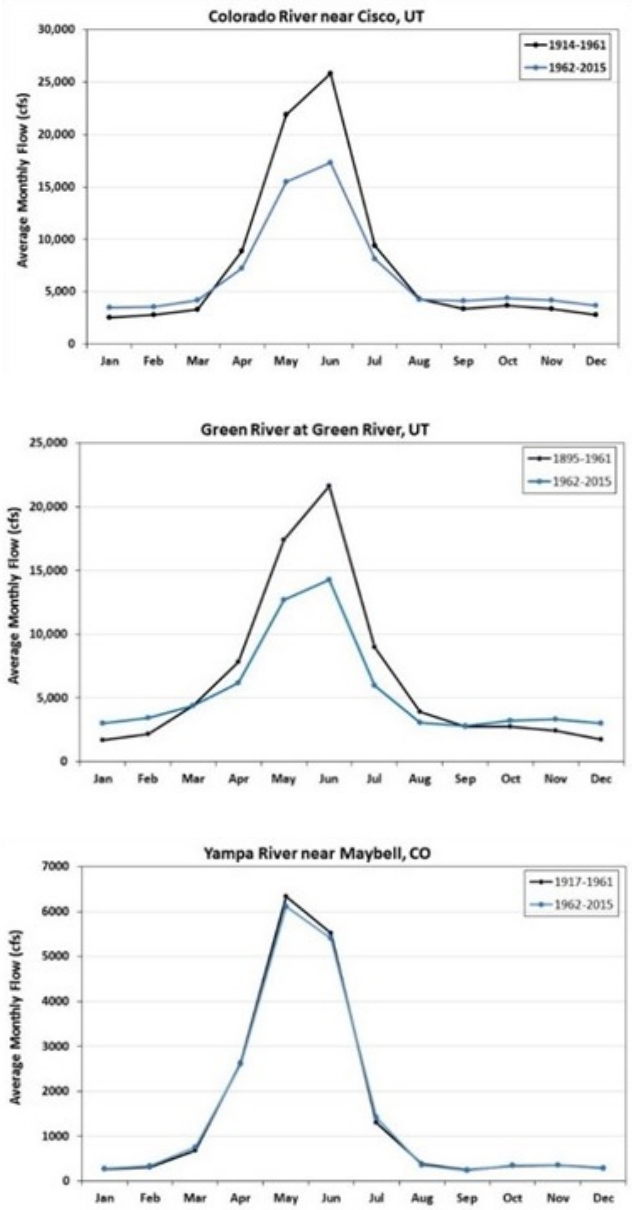


Figure 12. Mean monthly flows of the Colorado River near Cisco, UT (USGS #09180500); Green River at Green River, UT (USGS #09315000); and Yampa River near Maybell, CO (USGS #09251000) for the periods indicated. Source: http://waterdata.usgs.gov/usa/nwis/sw.

Low spring flow has been linked to increased numbers of Roundtail Chub in canyon habitats and the increased potential for competition and hybridization in the Black Rocks (Francis et al. 2016) and Westwater Canyon (Chart and Lentsch 1999) populations. High spring peaks are important for maintaining isolating mechanisms and fundamental ecological processes, including maintaining habitat diversity and minimizing invasion of other fish species, including nonnative predators. An invasion of Smallmouth Bass in the lower Yampa River and a decline in the Humpback Chub population are linked to reduced flow in 2000 (Haines et al. 2006).

UCRRP stakeholders have made great strides over the past 15 years to implement flow and temperature recommendations on the Green, Yampa, Duchesne, Colorado and Gunnison rivers with the intent of restoring aspects of a natural hydrograph (Table 4).

Temperature—Recent and ongoing drought in the Colorado River System have led to reduced stream flow, less than normal precipitation, and increased air temperature (Christensen et al. 2004; Reclamation 2012a, 2016). According to the Western Climate Mapping Initiative, mean annual air temperature during the 20th century has increased ~1.2°C in the upper basin and 1.7°C in the lower basin, which has continued into the 21st century. Temperatures of the Upper Colorado, Green, and Yampa rivers have increased over the last 40–65 years as a consequence of these weather phenomena (Bureau of Reclamation 2016).

From 1950 to 2015 (the last 65 years), cumulative daily water temperature by year (temperature degree-days) has increased ~13% in the Colorado River near Cisco, UT, 11% in the Green River at Green River, UT, and 13% in the Yampa River at Deerlodge Park, CO (Figure 13). Flow recommendations for the Green River (Muth et al. 2000), upper Colorado River (McAda 2003), and Yampa River (Roehm 2004) identify flow and temperature needed by the four native Colorado River fishes, but the effect of this temperature increase on the Humpback Chub has not been specifically investigated. Possibly, warmer temperature could lead to earlier spawning time and increased growth, but the effect on upper basin populations is largely unknown. Populations in the upper basin have persisted through historic periods of changing river flow and temperature, and it appears that the species is adapted to these types of changing environmental conditions.

The Humpback Chub is a long-lived, warm-water fish species whose many life functions are affected by water temperature, including growth. A comprehensive age-growth study of upper basin fish has not been done and the age composition of the five populations is unclear. Evidence indicates that individuals in the upper basin do not live as long as fish in the lower basin that reside in the cooler mainstem Colorado River (Meretsky et al. 2000), where their growth is slowed but longevity is apparently increased (Yackulic et al. 2014). Size and age at maturity varies with population, but generally Humpback Chub in the upper basin mature at 180–200 mm TL and at a presumed age of 3–5 years; whereas fish in the Grand Canyon take longer to mature. Individuals in the upper basin are typically smaller than fish from the lower basin, and likely produce fewer eggs. No current evidence indicates that warmer temperature has altered spawning time, growth, or any other life history function of the Humpback Chub in the upper basin.

Table 4. Flow Management Actions in the upper Colorado River System and Anticipated Effects to Humpback Chub

Flow Recommendations / Implementation	Flow Management Objectives	Flow Management - Performance Summary	HBC Target Populations	Anticipated Effects to HBC populations
Yampa River: Modde et al. 1999 / Yampa River Management Plan (Roehm 2004) & Yampa River Programmatic Biological Opinion (USFWS 2005a)	Maintain summer baseflow conditions at levels that provide fish passage for adult Colorado pikeminnow in lower Yampa River.	In 2007, UCRRP secured 5000 ac-ft in Elkhead Res. (w/ a lease option on 2000 add'l ac-ft) to augment summer base flows. Varying amounts have been used every year since 2007 in response to flow conditions.	Primary – DNM (Yampa Canyon); Secondary – DNM (Whirlpool Canyon) Desolation/Gray canyons	Augmentation water delivered to Yampa Canyon reduces the frequency and severity of periods of extreme low summer flow. The Elkhead Res. water is expected to improve UCRRP's chances of a successful repatriation of HBC in DNM.
Green River[A]: Muth et al. 2000 / Bureau of Rec. Flaming Gorge Res. Record of Decision (USDOI 2006)	Restore intra- and inter-annual flow and temperature variability from Flaming Gorge Dam downstream ~450 miles to the confluence with the Colorado River[B].	Since 2006, Reclamation has operated Flaming Gorge Dam to meet seasonal flow and temperature recommendations in virtually all years.	Primary – DNM (Whirlpool Canyon) and Desolation/Gray canyons, Secondary – Cataract Canyon	Promotes concepts of the Natural Flow Paradigm (Poff et al. 1997) expected to favor native over nonnative species. Operations to meet flow and temperature recommendations benefit native chubs in Whirlpool Canyon. Increased magnitude and duration of the spring peaks reduces influxes of nonnative Smallmouth Bass in Whirlpool and Desolation/Gray canyons.
Colorado River upstream of Gunnison confluence (15 Mile Reach): Osmundson et al 1995 / 15 Mile Reach Programmatic Biological Opinion (USFWS 1999)	Augment annual base flow and spring peak conditions to restore intra- and inter-annual flow and variability for adult Colorado pikeminnow and Razorback Sucker.	Reclamation and water users make 80-90KAF available to augment spring peak in the 15 Mile Reach by as much as 2000 cfs[C]. Baseflow augmentation occurs every year and improves summer flows by 400-500 cfs.	Primary – Black Rocks and Westwater Canyon, Secondary – Cataract Canyon	Colorado River and Gunnison River management in tandem promote concepts of the Natural Flow Paradigm (Poff et al. 1997) expected to favor native over nonnative species. Increasing the magnitude and duration of the spring peaks in Black Rocks and Westwater (and to a lesser extent in Cataract Canyon) is expected to favor Humpback Chub over native Roundtail Chub and continue to preclude invasion and proliferation of nonnative Smallmouth Bass in Black Rocks and Westwater Canyon.
Gunnison River & Colorado River below confluence : McAda 2003/ Bureau of Rec. Aspinall Record of Decision (USDOI 2012)	Same as above, but also to benefit Humpback Chub.	Reclamation has operated the Aspinall unit to achieve these objectives since 2012 and has demonstrated good performance meeting seasonal flow targets	Primary – Black Rocks and Westwater Canyon, Secondary – Cataract Canyon	

[A] Similar flow management occurs on the Duchesne River (a tributary to the Green) at a smaller scale and is not listed here. [B] Five sets of year round flow recommendations correspond to five hydrologic year types ranging from dry to wet. [C] Augmentation has occurred 10 times since 1997 under the Voluntary Coordinated Reservoir Operations (CROS).

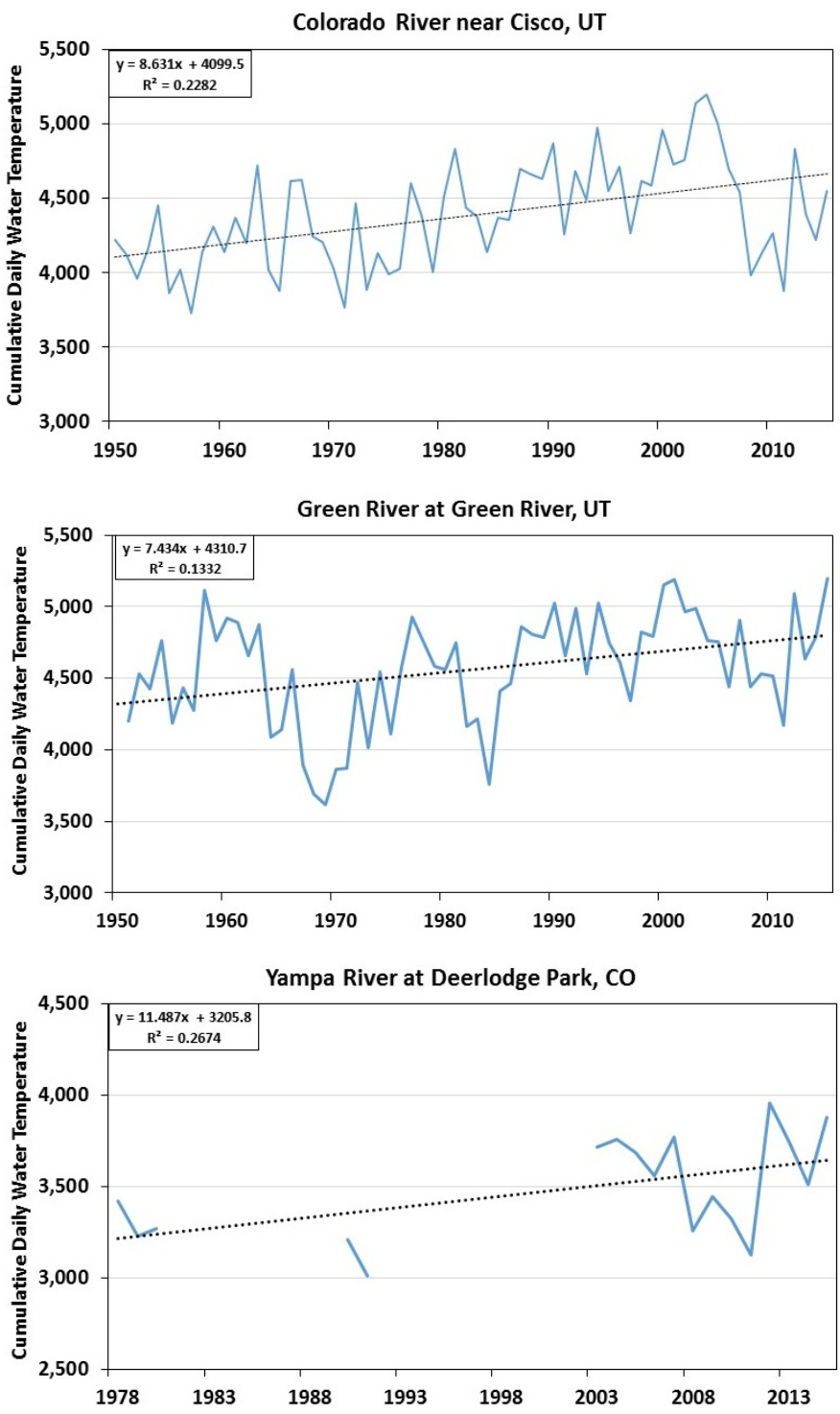


Figure 13. Cumulative daily temperature by year for the Colorado River near Cisco, UT (09180500), and the Green River at Green River, UT (09315000) from 1950 to 2015, and for the Yampa River at Deerlodge, CO (09260050) for available data from 1978 to 2015. Cumulative daily temperature is the additive of daily water temperature for each year, as an indicator of temperature degree-days (TDDs) for the year. The line of best fit represents an increase in TDDs over the period of record.

The temperature regimes of rivers in the upper basin have been changed locally by stenothermic releases from mainstem dams, although this effect does not currently extend to the upper basin Humpback Chub populations. Only the population in the Green River within DNM (Whirlpool Canyon and Island Park) has possibly been reduced by cold releases from Flaming Gorge Dam (USFWS 1990), in combination with invasion of nonnative predators, such as Smallmouth Bass. A temperature control device was installed on the dam in 1976 to warm dam releases, and native fishes (but not Humpback Chub) have recently expanded upstream into Lodore Canyon (Bestgen et al. 2006).

4.1.3 Adequate and Reliable Food Supply—The following is a summary of the food supply in populations of the upper basin followed by a detailed description:

- Mid-to low elevation rivers in the upper basin are dominated by allochthonous carbon sources that provide energy for primarily heterotrophic production;
- There is little autotrophic photosynthetic production in the main river channel because of ongoing turbidity, except at times of low flow in fall and early winter;
- The benthic community of Cataract Canyon is comprised of 23 taxa, mostly mayflies, caddisflies, and diptera that are dominated by filterer/collector species;
- Invertebrate biomass is determined by available primary carbon that is controlled by discharge patterns including large landscape floods that wash organic matter into the river; and
- Aquatic and terrestrial sources of carbon that provide food for Humpback Chub in the upper basin currently appear suitable and largely unchanged.

Humpback Chub eat a variety of foods, primarily aquatic and terrestrial macroinvertebrates. The macroinvertebrate communities of upper basin populations has been quantitatively described for Cataract Canyon (Haden et al. 2003), the Green River above and below the mouth of the Yampa River, and the lower Yampa River (Holden and Crist 1981). In Cataract Canyon, high suspended sediment inhibits primary production year-round, and the primary carbon source for benthic invertebrates is of terrestrial origin, washed into the river by large landscape floods. The invertebrate assemblage of Cataract Canyon and the Green and Colorado rivers near their confluence is dominated by three orders of aquatic insects (, EPT: Ephemeroptera, Plecoptera, Trichoptera), including 16 genera of mayflies (E), 7 genera of stoneflies (P), and 7 genera of caddisflies (T) (Haden et al. 2003). The assemblage in Cataract Canyon is comprised of 23 taxa, mostly mayflies, caddisflies, and diptera that are dominated by filterer/collector species, compared to 49 for upstream alluvial cobble bars. A smaller portion of the community is made up of predatory stoneflies and odonates (damselflies and dragonflies). In 2001, mean invertebrate biomass on cobble of the Green River was 0.41 g/m^2 ash-free dry weight, but lower in Cataract Canyon

For the Green River, 66 macroinvertebrate forms (families and genera) inhabited the reach between the Flaming Gorge Dam site and Ouray, Utah. After the dam was closed in 1962,

only 52 invertebrate taxa were reported, including 38 taxa found above and below the confluence of the Yampa River (Holden and Crist 1981). Pearson et al. (1968) found that the macroinvertebrate community had not been markedly altered by Flaming Gorge Dam below the Gates of Lodore (105 km downstream), although profound changes occurred in the community near the dam. Evidently, stenothermic releases from Flaming Gorge Dam affected the macroinvertebrate community of the Green River in DNM, and combined with predation and competition from nonnative fishes (e.g., Smallmouth Bass), as well as an historic rotenone treatment (Holden 1991), led to the decline of the Humpback Chub. It is unclear if the macroinvertebrate community described by Haden et al. (2003) for Cataract Canyon is similar to that of the four other upper basin populations, but the diet of chubs examined from these populations reveals the same suite of invertebrate species. Stomach contents of juvenile *Gila* (Humpback Chub or Roundtail Chub) from Desolation/Gray canyons show that the fish fed primarily on mayflies, midges, stoneflies, caddisflies, terrestrial invertebrates, and invertebrate remains (Jacobi and Jacobi 1982).

Humpback Chub in Cataract Canyon have been observed feeding on food items from the water's surface that can change with event, indicating that the species is capable of switching diet according to available food supply (Valdez 1990). Humpback Chub feed heavily on floating material entrained in eddies and low-velocity areas, as well as on sporadic food supplies brought on by large flow events or seasonal phenomena, such as mayfly hatches, grasshopper infestations, or migrating Mormon crickets (*Anabrus simplex*; Vanicek 1967; Tyus and Minckley 1988).

The biological processes of mid-to low elevation rivers in the upper basin are dominated by allochthonous carbon sources that provide energy to primarily heterotrophic production. There is little autotrophic photosynthetic production because the river is nearly always turbid, except at times in fall and early winter. The majority of food items used by river fishes include aquatic invertebrates (primarily insects) and terrestrial insects. The ecosystem that supports these conditions appears to be largely intact in the upper basin, and the current food supply for the Humpback Chub appears to be adequate and reliable.

4.1.4 Habitat With Few Nonnative Predators and Competitors—The following is a summary of predators and competitors in populations of the upper basin followed by a detailed description:

- ~50 species of nonnative fish have been introduced into the upper Colorado River System in the last 100 years, with 18 nonnative fish species inhabiting the same areas as Humpback Chub populations;
- Smallmouth Bass, Northern Pike, and Channel Catfish are predaceous introduced fishes which have established reproducing populations in certain locations in the upper Colorado River System. Walleye and Largemouth Bass are predaceous, non-recruiting introduced fishes that exist in the river primarily from emigrating from reservoirs (or ponds);

- Channel Catfish reside and recruit in Humpback Chub population areas; Smallmouth Bass occur in a subset of Humpback Chub population areas but rarely recruit there; Largemouth Bass can occur and do not recruit in Humpback Chub population areas; Northern Pike and Walleye are rare or absent from Humpback Chub population areas;
- Smallmouth bass are common in Desolation Canyon and have apparently expanded their range downstream throughout the canyon over the last decade, are present in low densities in the Dinosaur National Monument population and in Ruby Horsethief Canyon (surrounding Black Rocks), and are rare in Cataract and Westwater Canyons;
- Annual fluctuations in Smallmouth Bass density and size structure in Humpback Chub habitats are influenced by emigration from upstream areas. Warm summer base flow from low snowpack increases Smallmouth Bass production system-wide, whereas higher spring and summer flows decrease Smallmouth Bass production;
- Channel Catish densities in Humpback Chub populations are assumed to stable over the last 50 years, potentially indicating non-deleterious sympatry with Humpback Chub. Channel Catfish popualtions are more dense in Desolation Canyon, Cataract Canyon, and DNM;
- Largemouth Bass encountered in rivers of the upper basin are do not recruit to adult size classes; most individuals encountered are less than 250 mm. Catch rates are related to flow, with increased catch after large flow years that allow Largemouth Bass to emigrate from off-channel ponds. Largemouth Bass are only encountered near Black Rocks and Westwater Humpback Chub populations; and
- Nonnative fish management is ongoing in the upper basin to reduce the impact of nonnative predators and competitors on all native fishes.

The Humpback Chub evolved in an environment relatively free of predators and competitors, and is ill-adapted to living with the many nonnative fish species that have been introduced into the Colorado River System. The Humpback Chub is a soft-rayed fish with no defense mechanisms, such as sharp scales, teeth, or spines for protection from predators. Nonnative fish first appeared in the Colorado River in the late 1800s and early 1900s, with the import of fishes from other continents and river basins as food, such as Common Carp and Channel Catfish (Miller 1961; Minckley 1991). Additional introductions of various species took place in the mid-1900s with the development of reservoir sport fisheries, such as in Lake Mead (1935), Flaming Gorge Reservoir (1962), and Lake Powell (1963).

Nearly 70 species of nonnative fish have been introduced into the Colorado River System in the last 100 years, including ~50 species in the upper basin (Tyus et al. 1982; Carlson and Muth 1989; Lentsch et al. 1996; Valdez and Muth 2005). Since the late 1990s, few additional species have been introduced, although ranges and densities of these species have shifted.

Altogether, 18 species of nonnative fish occupy the same areas as Humpback Chub; additional species are uncommon or rare in these areas. Humpback Chub populations have persisted in the presence of these nonnative fishes for about the last 50 years (Figure 14).The density of nonnative fish species in canyon-confined areas occupied by Humpback Chub is generally lower than in adjacent low gradient areas (see discussion below) because of the more arduous hydrological conditions of canyon areas (Valdez and Clemmer 1982; Chart and Lentsch 1999).

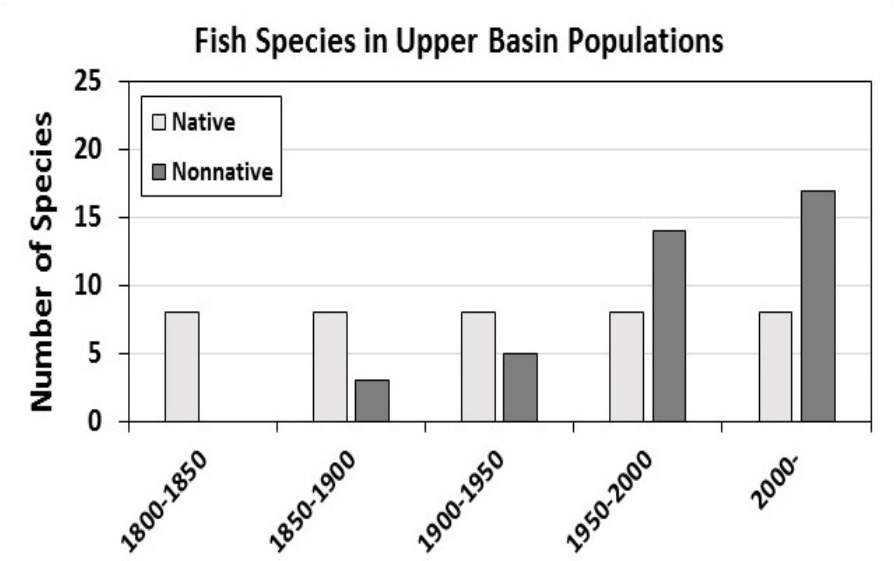


Figure 14. Numbers of native and nonnative fish species in Humpback Chub populations of the upper Colorado River basin.

In the upper Colorado River System, Smallmouth Bass, Largemouth Bass, Walleye, Channel Catfish, and Northern Pike are predatory nonnative fish of concern. Northern Pike and Smallmouth Bass are highly fecund in certain reaches of the upper Colorado River System, but typically not in Humpback Chub habitats; Largemouth Bass and Walleye are primarily emigrants from reservoirs, having not been documented as recruiting in riverine portions of the upper Colorado River System. Channel Catfish occur throughout the upper Colorado River System but are not considered predacious until they reach large adult sizes. Key ecological metrics for nonnative species of interest are shown in Table 5.

Smallmouth Bass present the highest potential impacts to Humpback Chub because the species can co-occur with Humpback Chub in certain canyon habitats and is a potential predator across its entire life history. However, canyon-bound reaches in the upper basin are not preferred habitats of Smallmouth bass, and are not characterized as Smallmouth Bass production areas, which greatly reduces the long-term sympatric density (Table 6).

Smallmouth Bass density and size structure in canyon habitats are influenced by emigration from nearby habitats rather than local production, reducing densities of Smallmouth Bass in average and wetter flow years, such as 2015 and 2016. Catch rates of Smallmouth Bass in

Humpback Chub population centers typically increase in years during or immediately following substantial nearby production, but then decline in subsequent years if nearby production is limited. This concept can be seen in the densities of Smallmouth Bass in Desolation Canyon in 2014, following the 2013 production in the middle Green River (Table 6). Similarly, densities in Ruby-Horsethief Canyon surrounding Black Rocks increased in 2013 and 2014 in response to 2013 production in the Grand Valley, but rapidly declined in 2015 and 2016. This cyclical density pattern reduces the long-term impact of Smallmouth Bass on Humpback Chub under adequate flow regimes.

Table 5. Ecological characteristics for nonnative fish of impact to upper basin populations of Humpback Chub, with a qualitative risk assessment.

	Smallmouth Bass	**Channel Catfish**	**Largemouth Bass**	**Walleye**	**Northern Pike**
Does the species recruit in riverine habitats?	Y, primarily in alluvial reaches	Y, basin wide	N, very few adult fish	N, emigrate from reservoirs	Y, in cold water reaches
Is the species sympatric with Humpback Chub?	Y, in some populations [A]	Y	Y, in some populations [B]	N, uncommon	N, rare
Does the species persist in Humpback Chub populations?	N, limited recruitment	Y, wild recruitment	N,	N, primarily migrating individuals	N, habitat & temperature unsuitable
Is the species always a potential predator to Humpback Chub?	Y, piscivores at early age	N, piscivores at larger sizes	Y, piscivores at early age	Y, piscivores at early age	Y, piscivores at early age
Humpback Chub populations of interest	Black Rocks, Desolation Canyon & DNM	All	Black Rocks and Westwater	All except DNM	DNM
Overall Risk	**Moderate/ High in DNM & Desolation; Low elsewhere**	**Low /Moderate**	**Low /Moderate**	**Low**	**Low**

[A] annually fluctuating densities of sympatry in DNM and Desolation Canyon, Rare sympatry in Westwater and Black Rocks, species absent in Cataract
[B] annually fluctuating densities of sympatry

Table 6. Smallmouth bass removal data (fish per hour and total catch) both within Humpback Chub populations (bolded) and adjacent river reaches since 2013. Effort, timing, and sizes removed may not be standardized. NR = Not reported; NS = Not sampled.

Location	River Miles	Smallmouth Bass removed per hour (Total individuals removed)				Reference
		2013	2014	2015	2016	
Yampa River						
Middle Yampa River	151 to 47.5	15.5 (10,267)	17 (11,710)	22.7 (13,074)	12.6 (7249)	Hawkins et al. 2013, 2014, 2015, 2016
Yampa Canyon (DNM population)	46 to 0	9.07 (1659)	23.7 (3966)	8.16 (1139)	8.62 (829)	Jones 2016
Yampa & Green River confluence						
Green River						
Lodore Canyon		2.7 (NR)	1.6 (38)	1.2 (26)	1.2 (27)	Bestgen et al. 2014, 2015, 2016 CPUE data provided by authors
Yampa & Green River confluence						
Whirlpool Canyon (DNM population)		7.3 (NR)	5.1 (71)	3.0 (46)	1.9 (24)	Bestgen et al. 2014, 2015, 2016 CPUE data provided by authors
Island Park	344.5 to 319.5	21.1 (5,913)	12.1 (2,768)	3.15 (787)	4.17 (1,016)	Jones & Howard 2013, Jones et al. 2014 , 2015, & 2016
Middle Green River	319.3 to 206.8	48.6 (20,210)	16.97 (5,539)	6.55 (2,738)	6.45 (2,003)	Staffeldt et al. 2016
Desolation & Gray canyons	206.8 to 128	NS	16.22 (1,626)	2.28 (286)	1.75 (69)	Jones et al. 2014, 2015, & 2016
Lower Green River	128 to 0	NR	NR	NR	(2)	Bestgen et al. 2016
Upper Colorado River						
Grand Valley	193.7 to 152.6	9.01 (2640)	2.06 (916)	1.23 (472)	1.56 (462)	Francis 2016 (data modified from Table 1)
Ruby Horsethief (includes **Black Rocks**)	152.6 to 124.8	9.10 (649)	2.53 (166)	0.72 (41)	0.42 (19)	
Westwater Canyon	124.8 to 111	NS	NS	1.19 (9)	0.39 (5)	Hines, unpublished data 2017
Cisco to Potash, Utah	111 to 47.2	0.40 (29)	0.42 (61)	0.21 (46)	0.10 (21)	Francis 2016

Channel Catish densities in Humpback Chub populations are assumed stable over the last 50 years, potentially indicating non-deleterious sympatry with Humpback Chub. Channel Catfish popualtions are more dense in Desolation Canyon, Cataract Canyon, and DNM . UCRRP experimented with Channel Catfish removal in the 1990s but determined that work to be ineffective. Crews now only remove Channel Catfish of sizes deemed predatory to large native fishes (greater than 400 mm). These individuals are captured in low densities. Catches of large Channel Catfish are typically in the single digits in Humpback Chub population areas.

Largemouth Bass encountered in the upper Colorado River do not recruit to adult size classes; most individuals encountered are less than 250 mm. Catch rates are related to flow, with increased catch after large flow years that allow Largemouth Bass to emigrate from off-channel ponds. Largemouth Bass are only encountered near Black Rocks and Westwater Humpback Chub populations.

In contrast, Walleye and Northern Pike do not typically occupy the warm-water, canyon-bound reaches occupied by Humpack Chub. Catches of these two species are low, especially when compared to other upper basin locations, such as Walleye catches in alluvial reaches (Figure 15) and Northern Pike catches in cold water reaches. Captures are characterized by adult sizes, which are presumably migrating adults.

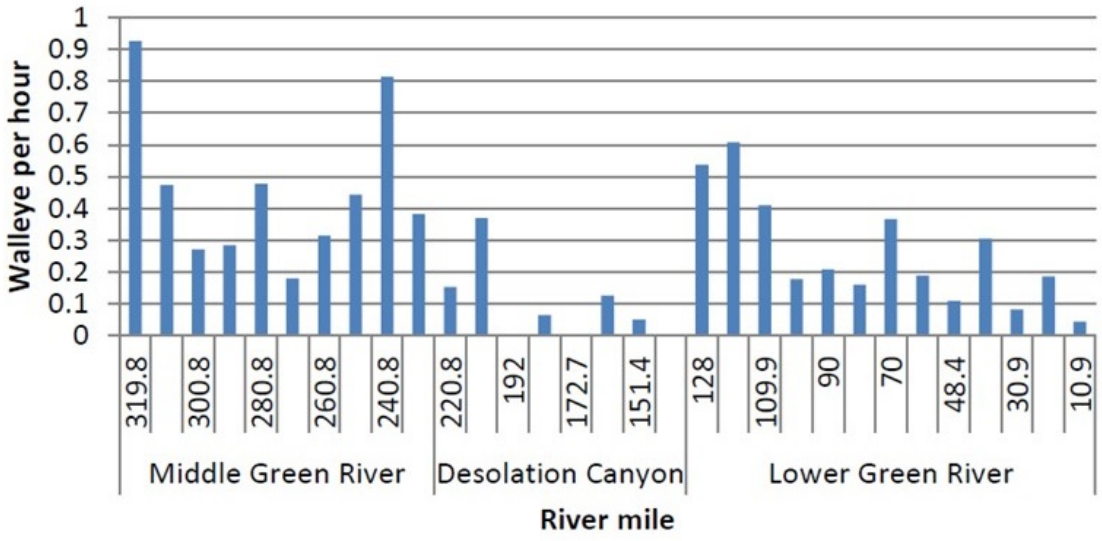


Figure 15. Catch per unit effort for Walleye on the Green River from April 9 to June 8, 2016. Figure from Michaud *et al.* (2016). The Middle Green River and the upper portion of the Lower Green River (RM 128 to 109.9) are alluvial reaches that display denser catches of Walleye.

Black Rocks—The primary species of concern in Black Rocks are Smallmouth and Largemouth Bass. In the Colorado River, Smallmouth Bass production is centered in the Grand Valley reach upstream of Humpback Chub populations. Nonnative removal in Ruby-

Horsethief Canyon (including the Black Rocks Humpback Chub population and other locations not occupied by Humpback Chub) is conducted to monitor the nonnative fish community and remove any individuals moving downstream. Catch rates from specific nonnative fish removal and monitoring of Humpback Chub indicate that densities of Largemouth and Smallmouth Bass can increase in response to upstream production, but that densities return to lower levels within a couple of years. Specifically, Smallmouth Bass in Ruby-Horsethief Canyon were consistently low from 2004 to 2012, but elevated Largemouth Bass catch rates in Black Rocks during fall Humpback Chub monitoring in 2012 (RM 7 to 78) prompted increased removal effort in subsequent years (Francis et al. 2016). Similarly, catch rates of Smallmouth Bass during nonnative removal in Ruby-Horsethief Canyon greatly increased in 2013 and 2014 (Table 6, above), potentially a result of downstream dispersal from extensive upstream production. However, Smallmouth Bass catches decreased substantially in subsequent years (78% from 2014 to 2015; and declining again in 2016) (Figure 6 from Francis 2016 and Table 6, above). Even more importantly, only three Smallmouth Bass and only 14 Largemouth Bass were removed during Humpback Chub monitoring in the Black Rocks reach occupied by Humpback Chub in 2016 (Francis and Ryden 2016).

Westwater Canyon—The primary species of interest in Westwater Canyon are Smallmouth Bass and Walleye. Smallmouth bass captures in Humpback Chub habitats downstream of Ruby-Horsethief Canyon are rare (Table 6); in 2016, five Smallmouth Bass were captured in Westwater monitoring (Hines 2016). Some nonnative removal effort does take place downstream of Westwater Canyons, primarily focused Walleye removal in spring and fall. Walleye catch rates have been declining in this reach since 2013, and most fish are captured in the Moab and Cisco reaches downstream, not in Westwater Canyon (Michaud et al. 2016). Smallmouth Bass are removed as part of this effort, but catch rates are typically low. Juvenile and adult Smallmouth Bass removal rates were less than 0.5 fish per hour every year, and declined from 2014 to 2015 to 2016 (Francis 2016). However, of concern was the fact that a localized high density of fish greater than 325 mm were collected from Cisco to Dewey Bridge, UT in 2014 and 2015, but catch rate did decrease in 2016 (Francis 2016). Northern pike are rarely caught during in-river removal near Westwater or Black Rocks, with only three captured in the upstream Grand Valley reach in 2016, and one captured near Cisco, Utah; all four were large adults (Francis 2016).

Dinosaur National Monument—The primary species of concern in Dinosaur National Monument are Smallmouth Bass, Channel Catfish, and Northern Pike. The Dinosaur National Monument population occurs in Yampa and Whirlpool canyons in the Yampa and Green rivers, respectively. Both canyons are dominated by native fish despite being in near proximity to high production areas of Smallmouth Bass and Northern Pike, indicating that habitats are not conducive to these nonnative fish. Monitoring in Yampa Canyon indicates native Flannelmouth and Bluehead Suckers have dominated the fish community over the past decade (>75% of the abundance), with Channel Catfish moderately abundant, and Roundtail Chub and Smallmouth Bass present in low abundance (Jones 2016).

Native fishes similarly dominate in Whirlpool Canyon, where 70% of all fishes collected in 2016 were native (71% in 2015) (Bestgen et al. 2016).

Catch rates of Smallmouth Bass in Yampa and Whirlpool Canyons increased in 2013 (Whirlpool Canyon) and 2014 (Yampa Canyon) in response to high production in nearby Island Park and middle Yampa reaches in 2012 and 2013 (Table 6). However, densities of Smallmouth Bass in these reaches declined to lower levels in subsequent years (Bestgen et al. 2016, Jones 2016). This demonstrates that Smallmouth Bass are not able to establish in high densities over the long term. Both Walleye and Northern Pike catch rates in the Dinosaur National Monument population are uncommon or rare. Catch rates of Walleye in Whirlpool and Yampa Canyons were lower than 0.05 fish per hour in 2016 (Table 6 and 7 in Michaud et al. 2016). Similarly, Northern Pike catch rates in Yampa Canyon averaged 12 fish per year, and have been declining since 2013[5] (Jones 2016); Northern Pike abundance in Whirlpool Canyon is low and none were captured in 2013-2016 (Bestgen et al. 2016). Neither Northern Pike nor Walleye are known to reproduce in the local area, but Northern Pike do reproduce upstream in both the Yampa and Green rivers. Walleye are likely emigrating from reservoir sources such as Red Fleet and Starvation reservoirs, which are now screened, or Lake Powell.

Desolation/Gray canyons—The primary nonnative fish of concern in Desolation and Gray canyons is Smallmouth Bass. While Smallmouth Bass have been documented in Desolation Canyon since the initial basin-wide increase in the early 2000s, Desolation Canyon is considered a limited Smallmouth Bass production area because most individuals in this reach come from upstream production areas. Walleye and large Channel Catfish are uncommon in Desolation and Gray canyons and Northern Pike are rare.

In monitoring efforts prior to 2014, Smallmouth Bass were typically encountered in lower densities than other nonnative species, such as Channel Catfish. However, catch rates were elevated in 2014 following high Smallmouth Bass production in upstream reaches in 2012 and 2013 (Table 6). Catch rates returned to modest levels in subsequent years and indicate that Smallmouth Bass recruitment has been limited since 2014 (Jones et al. 2016). The central point of concern is that Smallmouth Bass have apparently expanded their range since the mid-2000s. Recent sampling indicated that Smallmouth Bass continue to be found throughout the Desolation/Gray reach (Jones et al. 2016). After the large influx of individuals in 2014, catch rates returned to previously documented levels in 2015 and 2016, but fish produced in 2014 remain present (Jones et al. 2015).

Warm waters likely limit Northern Pike occupancy in Desolation/Gray canyons. Northern pike are a rare catch in this reach, with crews removing only one individual in each of 2014 (Jones et al. 2014) and 2015 (Jones et al. 2015), and none in 2016 (Jones et al. 2016). Walleye are of low to moderate concern in Desolation/Gray canyons. Catch rates do not

[5] Specific catches were 16, 14, 10, and 8 Northern Pike in 2013, 2014, 2015, and 2016, respectively. These data are presented in Table 2 of each annual report for the UCRRP's Project 110.

warrant targeted removal of Walleye in this reach, but continued removal during other projects is justified (Michaud et al. 2016). Walleye density is much lower in Desolation/Gray canyons compared to more low gradient reaches upstream and downstream (Figure 15). Large Channel Catfish (greater than 400 mm) are also removed when encountered, but captures of these individuals is typically less than 10 individuals per year (Jones et al. 2014, 2015, and 2016).

Cataract Canyon—Specific nonnative removal actions are not conducted in Cataract Canyon, so nonnative captures are wholly a result of Humpback Chub monitoring conducted in autumn. However, it is worth noting that Smallmouth Bass and Northern Pike are very rare below Desolation Canyon on the Green River and very rare below the Grand Valley reach on the Colorado River. Because Cataract Canyon is immediately upstream of Lake Powell, it is expected that emigrating Walleye pass through the canyon. However, Walleye catches within the canyon are rare. In 2015, no Walleye, Northern Pike, or Smallmouth Bass were captured during Humpback Chub catch per unit effort estimates (Ahrens 2015). In 2013, three Walleye were captured (Howard 2013) and no Smallmouth Bass or Northern Pike. These catch rates, combined with Cataract Canyon's low latitude and high gradient, indicate that nonnative fish do not likely occupy this population in meaningful densities.

4.1.5 Suitable Water Quality—The following is a summary of water quality conditions in populations of the upper basin followed by a detailed description:

- Many water contaminants have been identified, but the effects of these on Humpback Chub have not been specifically investigated;
- Selenium and mercury have been identified as having physiological effects on Razorback Sucker and Colorado Pikeminnow, but effects on Humpback Chub are unknown;
- Catastrophic spills of hazardous materials, such as petroleum products or other chemicals are a potential threat to water quality and to Humpback Chub;
- These types of spills have occurred in Yampa Canyon but the effect was not documented;
- Another potential catastrophic threat is ash and debris flows from large rainstorms following range fires; these have occurred in Westwater Canyon and Desolation/Gray canyons; and
- Water quality is not known to be limiting Humpback Chub populations in the upper basin.

Water Quality and Contaminants—Since 1995, the National Stream Quality Accounting Network (NASQAN) of the U.S. Geological Survey (USGS) has monitored the water quality of the Colorado River (Hart and Hooper 2000). Many contaminants have been

identified, but the effect of these on the Humpback Chub has not been specifically investigated, other than what is generally known about the effect of various contaminants on fish.

Some water contaminants may incorporate into body tissue of newly-hatched larvae and cause adverse physiological effects, deformities, or death. For example, vertebral defects and spinal deformities can be caused by heavy metals (e.g., arsenic, cadmium, copper, lead, mercury, or zinc) or organochloride, and carbamate intoxications (Silverstone and Hammell 2002). Over 16% of young Roundtail Chub from the Yampa and Colorado rivers in 1981 had spinal deformities (lordosis) hypothesized to be related to high pesticide levels from local agricultural applications (Haynes and Muth 1981). No tissue analysis of Humpback Chub has been conducted to determine current levels of bioaccumulation or effects to individuals, although a low incidence of spinal deformity is reported in some populations, such as Black Rocks (Francis et al. 2016).

Selenium and mercury have been identified as having physiological effects on Razorback Sucker and Colorado Pikeminnow (Osmundson et al. 2000), but the effects of these elements have not been specifically investigated for Humpback Chub.

Catastrophic Spills— Catastrophic spills of hazardous materials, such as petroleum products or other chemicals are a potential threat to water quality and to Humpback Chub. The Denver and Rio Grande Western railroad tracks have paralleled the Colorado River at Black Rocks and upper Westwater Canyon since ~1883 (Bradley 1996); these pose a risk of derailment and spills of materials into the river, although no known derailment has occurred in these areas. The vulnerability of these populations to toxic spills is illustrated by a pipeline rupture in the late 1980's releasing refined oil into occupied Humpback Chub habitat in the Yampa River, but the effects of this spill were not documented. Numerous petroleum-product pipelines cross or parallel rivers in the upper basin. Existing and future oil and gas wells located near floodplains, arroyos, or washes are another potential spill source. The susceptibility of habitats to these spills is demonstrated by the 2014 well rupture near Green River, UT that spilled petroleum compounds into the Green River between Humpback Chub populations in Desolation/Gray canyons and Cataract Canyon[6].

Ash or debris flows from large rainstorms following range fires are a more natural catastrophic threat to Humpback Chub. These flows can deliver large amounts of mud, ash, and debris that can suffocate fish and macroinvertebrates; these debris flows often occur after range fires have denuded the landscape of vegetation and may contain fire retardant chemicals that could cause toxic fish effects. Such events killed unquantified numbers of Humpback Chub in Westwater Canyon in July 1989 (USFWS 2002) and in Desolation/Gray canyons in 2012 (Seeley Mountain Fire[7]). A similar event took place in Shinumo Creek of Grand Canyon in 2014 that killed or transported most fish downstream. A higher frequency

[6] (http://www.moabsunnews.com/news/article ce055ca4-e673-11e3-be35-001a4bcf6878.html)
[7] www.utahfireinfo.gov/

of drought appears to be increasing the incidence of range fires and possibly these types of ash and debris-laden floods.

4.1.6 Unimpeded Range and Connectivity—The following is a summary of connectivity among populations of the upper basin followed by a detailed description:

- Humpback Chub in the upper basin occur as four extant populations spaced 33–553 km apart, with no impediment to movement within or among populations;
- Numbers of individuals moving among populations is small, except between the most proximate populations in Black Rocks and Westwater Canyon, 33 km apart;
- There is no impediment to movement among the five upper basin populations, but transition of individuals is low and sufficient to ensure genetic exchange and diversity, but not sufficient to repopulated declined populations; and
- At a species level, Glen Canyon Dam is a barrier to movement between the upper and lower basins.

The Humpback Chub in the upper basin occurs as five disjunct populations with no impediment to movement, but with little exchange of individuals among populations, except between the most proximate in Black Rocks and Westwater Canyon. For the more distant populations, there has been a much lower exchange of individuals. From 1998 to 2011, the estimated annual probability of adults moving from Black Rocks to Westwater Canyon was 1.4% (6 of 404 adults), and from Westwater Canyon to Black Rocks was 1.8% (24 of 1,315 adults; Francis et al. 2016). These movements may be sufficient to affect recruitment and demography of the smaller Black Rocks population and there are sufficient numbers of individuals moving to ensure genetic exchange and diversity.

The STReaMS database reveals that from 1979 through 2014, a large number of Humpback Chub have been captured within population centers and a small number that have been captured or recaptured in between (Figure 16); these fish were captured under different sampling programs and with a variety of gears. Over 90% of fish captured from all programs in the upper basin have been caught within the five populations.

The database also shows that a few fish moved greater distances. Three fish moved from the Colorado River to the Green River, including one from Cataract Canyon to Desolation/Gray canyons (267 km), and one from Cataract Canyon to Bowknot Bend (103 km). Also, one fish moved from the Green River to the Yampa River (61 km), and one fish moved from the Colorado River to the Gunnison River (82 km). One Humpback Chub was detected in the Green River Canal at Tusher Wash in 2014 (tagged 2 days earlier in Desolation/Gray canyons) and one was detected in the canal in 2013 (tagged in 2010 in Desolation/Gray canyons).

Contemporary radiotelemetry and mark-recapture data show similar patterns of limited movement of Humpback Chub in the upper basin, with a few individuals making large movements. Two radio-tagged adults strayed ~10 km upstream from Black Rocks and returned to the population (Valdez and Clemmer 1982). More recently, 5 Humpback Chub were reported from the Grand Valley Water User's fish passage upstream of Grand Junction. One fish was captured in 2005, two in 2011, and two juveniles in 2017 (Francis and Ryden 2017). Also, two Humpback Chub were found dead on the upstream grates of the fish passageway in 2015. No Humpback Chub have been detected at the most downstream PIT tag antenna on the Price-Stubb dam, which indicates that the fish captured at the GVWU fish passage are from a relict population located at Beavertail Bend ~7 km upstream and first reported in 1980 (Valdez et al. 1982).

Small numbers of individuals have been captured outside of population centers, generally in enclaves of deep rocky habitat, such as in Elephant Canyon (Valdez 1990), Horsethief Canyon, and Beavertail Bend of the upper Colorado River (Valdez et al. 1982); below Bowknot Bend and in Whirlpool Canyon of the Green River (Tyus 1998); and in the Little Snake River (Wick et al. 1991). These outlying areas support persistently small numbers of Humpback Chub, but are not considered population centers.

Despite relatively long individual movements, most adult Humpback Chub display a high degree of fidelity to specific locales within their respective populations; movement of radio-tagged and PIT-tagged adults over 3 years was < 5 km (Valdez and Clemmer 1982; Kaeding et al. 1990). Of 1,552 fish (1,588 movements), 73% of recaptured fish remained within 10 miles (16 km) of their original capture location and 97% remained within 20 miles (32 km; Figure 17). Although there is no impediment to movement among the five upper basin populations, the transition of individuals appears low, and natural repopulation and demographic rescue of declined populations is unlikely.

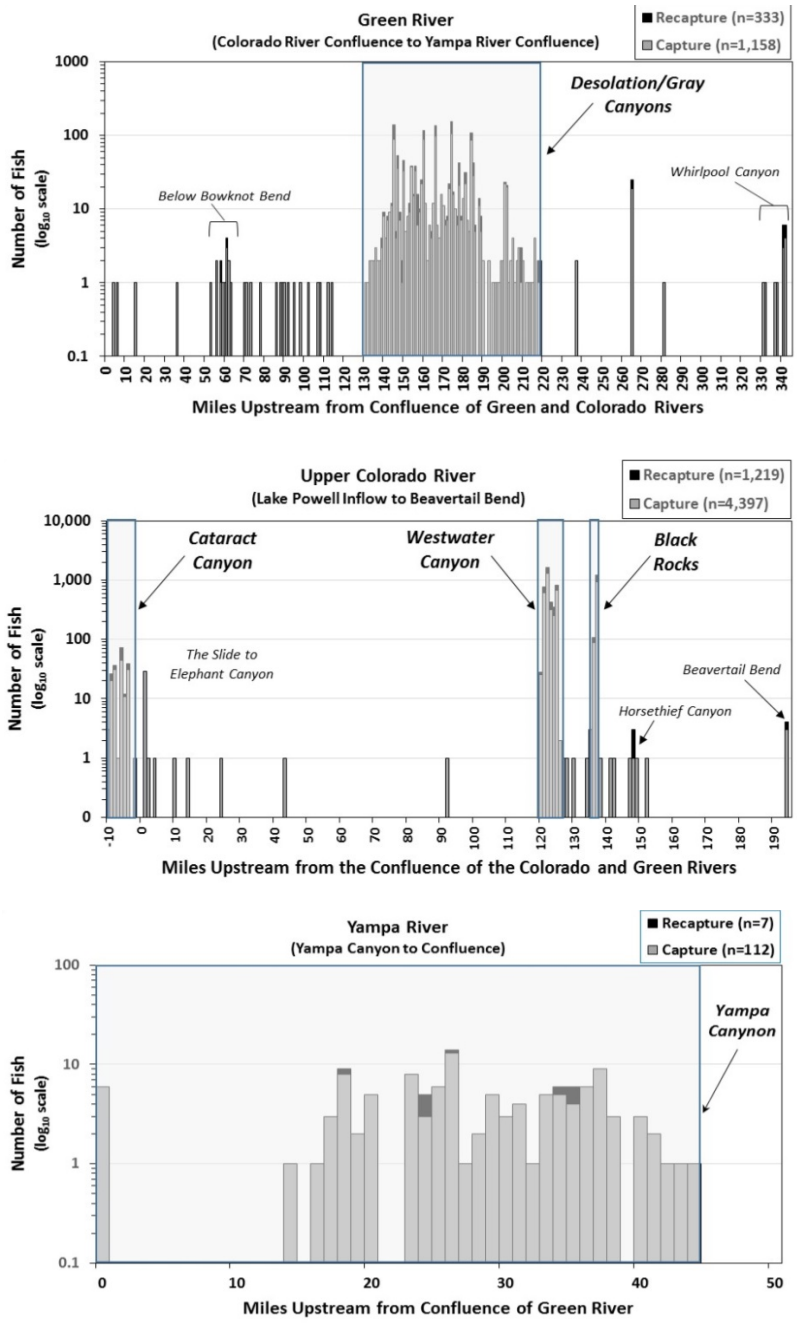


Figure 16. Distribution of Humpback Chub marked with PIT tags and recaptured or detected by remote antennas in the Green River (Colorado River confluence upstream to the confluence of the Yampa River), upper Colorado River (Lake Powell inflow upstream to Beavertail Bend, upstream of Grand Junction, Colorado), and Yampa River (Lily Park downstream to the confluence of the Green River), 1979–2014. Miles occupied by the five populations are shaded and identified. Data are preliminary from the Species Tagging Research and Monitoring System (STReaMS) database (https://streamsystem.org/), and do not include fish captured in earlier collections (e.g., Tyus et al. 1982; Valdez et al. 1982). Most tagged fish were ≥100 mm TL and the smallest fish was 68 mm TL. Numbers of fish are not adjusted for sampling effort.

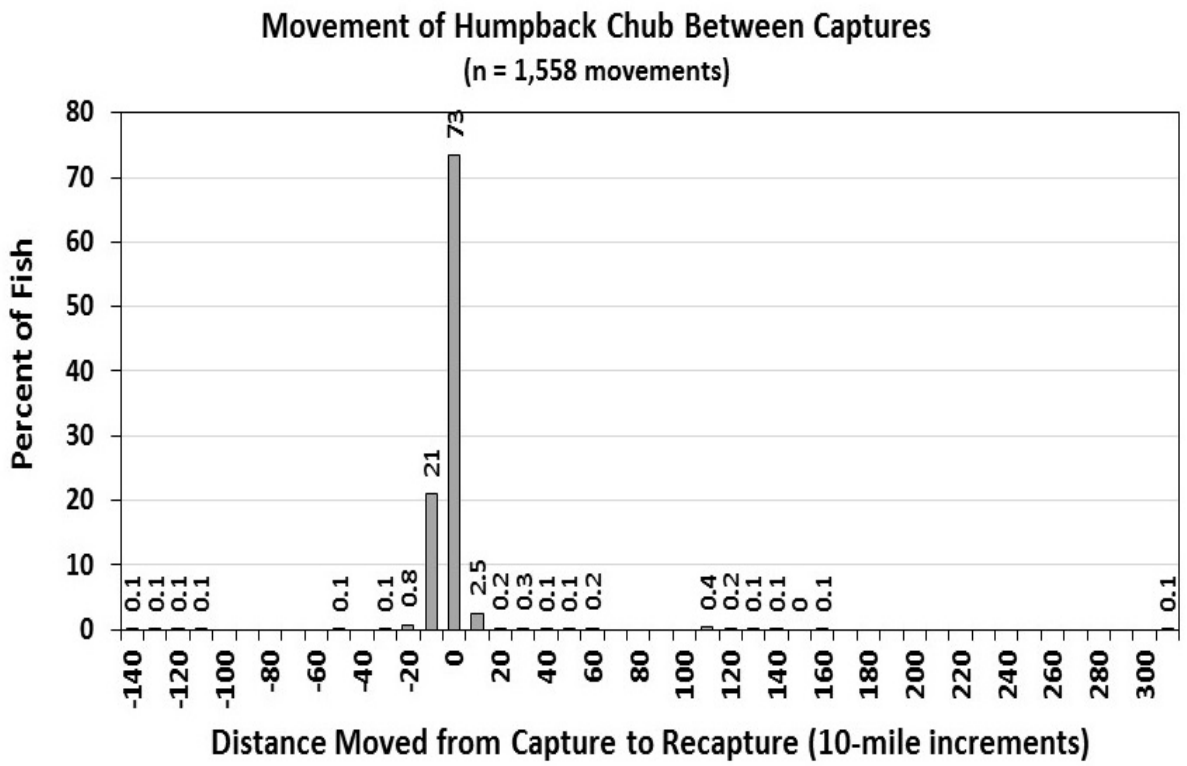


Figure 17. Movement of PIT-tagged Humpback Chub between capture and recapture locations in the upper Colorado River basin. Data are preliminary from the Species Tagging Research and Monitoring System (STReaMS) database (https://streamsystem.org/).

4.1.7 Persistent populations—The following is a summary of the populations in the upper basin followed by a detailed description (see section 4.5 for the demographic status of each population):

- Since 2007, mean sum of adults in the three upper basin populations with robust estimates is ~3,800, which is a period of apparent stability; the remaining two populations do not have recent robust estimates to report;
- The three largest populations in the upper basin supported 404 and 1,315 adults for Black Rocks and Westwater Canyon in 2012, respectively, and 1,672 adults in Desolation/Gray canyons in 2015;
- The smallest population is Cataract Canyon that ranged from 468 adults in 2003 to 295 in 2005;
- The DNM population is below detection limits and considered functionally extirpated. No Humpback Chub have been collected since 2004; and
- Four of the five upper basin populations are persisting.

Four of the five upper basin populations have persisted since they were first reported over 50 years ago, during the period 1960–1980 (Kidd 1977; Holden 1968; Valdez and Clemmer 1982; Valdez et al. 1982; Tyus et al. 1982; Tyus 1998). Adult numbers declined to about the year 2005 and have remained about the same afterward in Black Rocks, Westwater Canyon, and Desolation/Gray canyons. The population in Cataract Canyon has consisted of low numbers since it was discovered in 1979 (Valdez et al. 1982), and catch rates have not changed appreciably; the population is difficult to sample because of arduous whitewater rapids, deep-water habitats, and sparse distribution of fish (Badame 2008).

The numbers of adult Humpback Chub in upper basin populations have been monitored with mark-recapture methods starting with Westwater Canyon (1994–2012; Hines et al. 2016), Black Rocks (1998–2012; Francis et al. 2016), and Desolation/Gray canyons (2001–2015; Howard and Caldwell 2017). Estimates are done annually for two consecutive years followed by two years with no estimates to reduce handling and stress to the fish; estimates are staggered across populations because of personnel and budgetary constraints. Since 2007, mean sum of adults in the three upper basin populations with robust estimates is ~3,800, which is a period of apparent stability. The remaining two populations do not have recent robust estimates to report. The numbers of individuals in upper basin populations have varied over time, with the three largest populations most recently supporting 404 and 1,315 adults in Black Rocks and Westwater Canyon in 2012, respectively, and 1,672 adults in Desolation/Gray canyons in 2015. The smallest populations are in Cataract Canyon with 468 adults in 2003 to 295 in 2005, and in Yampa Canyon of the DNM population with 320 adults in 2001 to 224 in 2003. Individuals have not been collected in the DNM population since 2004 and it is therefore considered functionally extirpated.

The population in DNM has recently been restricted to the lower Yampa River where it appears to have declined with few fish remaining. In 2007, ~400 juvenile *Gila* spp. were taken from near Mantle's Ranch in Yampa Canyon for the purpose of establishing a refuge population (Upper Colorado River Endangered Fish Recovery Program 2009). About 200 live fish were transported each to the Ouray National Fish Hatchery, Ouray, Utah, and to the J.W. Mumma Aquatic Species Restoration Facility, Alamosa, Colorado. After the fish were large enough to identify, it was determined from visual morphological examination that there were no Humpback Chub in the sample (Melissa Trammell, National Park Service, Personal Communication, July, 2016). A sample of 28 specimens each subjected to msat DNA analysis were found to be genetically identical to the Roundtail Chub of that population, and no evidence of *G. cypha* was found in the Yampa Canyon samples (Bohn 2016). Subsequent sampling in Yampa Canyon has yielded few Humpback Chub (Jones 2012, 2013, 2014), but additional sampling is needed to determine the number of individuals that remain.

The Humpback Chub has not been translocated in the upper basin, but has been introduced from hatchery stocks once. In December of 1981, a total of 7,600 juvenile Humpback Chub were hatched and raised at the Willow Beach National Fish Hatchery and released in Cataract Canyon at 1½ years of age (Valdez 1990). These fish had been hatched from eggs taken from

ripe fish in Black Rocks in May 1980 (Arcadio Gonzales-Valdes, University of Mexico at Monterey, Personal Communication, October, 1980). Each released fish was marked with a coded wire nose tag, but fish caught in subsequent investigations have not been examined with a metal detector, and the survival, fate, and eventual influence of these fish on the population size and genetics of the Cataract Canyon population is unknown.

4.1.8 High Genetic Diversity—The following is a summary of the genetic diversity of populations in the upper basin followed by a detailed description:

- Ongoing hybridization between Humpback Chub and Roundtail Chub currently occurs in all five upper basin populations;
- Three genetic subgroups were identified for Humpback Chub in the upper basin, including one for Desolation Canyon, one inconclusive determination for DNM (Yampa Canyon), and one for all other populations; and
- The current genetic status of the Humpback Chub in the upper basin shows four of the five populations linked genetically over a decadal scale, each population reflects the suite of alleles and diversity representative of the species collectively.

Douglas and Douglas (2007) identified three genetic subgroups for the Humpback Chub in the upper basin, including one for Desolation Canyon, one inconclusive determination for Yampa Canyon, and one for all of the other populations (see section 2.4). The msat DNA showed evidence of genetic exchange among groups of fish at a decadal scale, with no significant differences in genetic diversity. Recent preliminary molecular analysis indicates that upper basin populations are diverse (except for Yampa Canyon) with no change in diversity in the last 10 years and no need for supplementation with lower basin genetics (Bohn and Wilson 2017). Bohn (2016) used msat DNA analysis and found no evidence of *G. cypha* in the Yampa Canyon samples taken in 2007, although the number of specimens was small (n = 24) and it could not be determined if *G. cypha* have disappeared from the Yampa River, or if they were simply not sampled in the study.

Ongoing hybridization between the Humpback Chub and Roundtail Chub occurs in all five upper basin populations; the number of Bonytail in the upper basin is small, but the species is being stocked annually, increasing the chance of hybridization with the two other *Gila* species. The proportions of species and intergrades from past collections provide a perspective of the level of hybridization in upper basin populations.

Recent studies show that in Black Rocks, the proportion of Humpback Chub and fish with morphologic characteristics of both Humpback Chub and Roundtail Chub compared to the proportion of Roundtail Chub has declined dramatically from 55:45 (average ratio for 1979–1981, 1983–1985, 1988, and 1991; USFWS 2002) to 9:91 in 2007–2008, and 20:80 in 2011–2012 (Francis et al. 2016). These proportions reflect increased abundance in Roundtail Chub, as trammel net catches of Humpback Chub and *Gila* species combined have remained fairly stable in 2007 (8.3%), 2008 (5.4%), 2011 (9.1%), and 2012 (8.8%).

The increased abundance of Roundtail Chub is thought to be related to years of low river flow, especially during spring runoff (Kaeding et al 1990; Chart and Lentsch 1999; Francis and McAda 2011), as low flow reduces water velocity and the arduous conditions that otherwise help to impede invasion of fish species into Humpback Chub populations. This relationship is further explained in Appendix B.

4.2 Lower Basin Current Resource Conditions

4.2.1 Diverse Rocky Canyon River Habitat—The following is a summary of rocky canyon habitat in the population of the lower basin followed by a detailed description:

- The species currently occupies rocky canyon habitat in ~406 km of the Colorado River through Marble and Grand canyons, and in ~24 km in the lower LCR, as well as lower Havasu Creek into which fish were translocated;
- The mainstem river channel is largely intact and without direct human effect, but Glen Canyon Dam has reduced sediment in the mainstem;
- The geomorphic framework of the lower LCR and Havasu Creek are also intact and located in remote areas with little direct human effect;
- Riverine habitat is expanding in western Grand Canyon, as Lake Mead has receded and eroded lake sediments, exposing the historical rocky channel; and
- Rocky canyon habitat in the Grand Canyon is on lands administered by Grand Canyon National Park and adjacent to Navajo, Hope, Hualapai, and Havasupai lands that protect the current condition of these areas.

The Humpback Chub in the lower basin currently occupies ~400 km of the Colorado River through Marble and Grand canyons, as well as the lower LCR and Havasu Creek. Talus shorelines and large recirculating eddies and deep pools are used by the species in the mainstem, and rocky channels with deep pools and riffles are used in the tributaries (Figure 18). This geomorphic structure is intact and largely unchanged, except for reduced sediment in the mainstem that is retained in Lake Powell; sediment downstream of Glen Canyon Dam is delivered by tributaries, principally the LCR and Paria River. Reduced flow magnitude has allowed an encroachment of shoreline vegetation, although these changes have not affected the species, except where vegetation has reduced backwater habitat (Stevens et al. 1997).

The Humpback Chub was once distributed downstream to the confluence of Spencer Creek (RM 246; Bookstein et al. 1985), but this lower end of the canyon was inundated by Lake Mead after Hoover Dam was constructed in 1936. Since 2002, the lake has receded and exposed historical habitat that is being increasingly occupied by the species.

The Grand Canyon region is on lands administered by Grand Canyon National Park, as well as the Navajo, Hope, Hualapai, and Havasupai tribes. These serve to protect the current

condition of resources in the Grand Canyon. Natural and cultural resources are further protected by the Grand Canyon Protection Act of 1992 (Title XVIII, Section 1801) that has established the Glen Canyon Dam Adaptive Management Program (GCDAMP) as a Federal Advisory Committee to the Secretary of the Interior. The GCDAMP includes 23 stakeholder groups and a research branch (Grand Canyon Monitoring and Research Center) dedicated to advising the GCDAMP on protecting canyon resources through scientific investigation.



Figure 18. Rocky canyon habitat used by Humpback Chub in Grand Canyon, including debris fans and recirculating eddies in the mainstem Colorado River, talus shorelines in the mainstem, the mouth of the LCR, and travertine dams with deep pools in the LCR.

4.2.2 Suitable River Flow and Temperature—The following is a summary of flow and temperature conditions in the population of the lower basin followed by a detailed description:

- Flow and temperature of the Colorado River through the Grand Canyon have been altered by the closure and operation of Glen Canyon Dam starting in 1963;
- Despite flow change, the species continues to use the mainstem for all life stages, except spawning, egg incubation, and larval development, which occur primarily in the LCR;
- Juveniles are able to use available shoreline habitat under the range of allowable dam releases and a daily flow change of up to 8,000 cfs;
- Adults appear to adjust to changing flow conditions under large controlled floods of up to 45,000 cfs;

- Temperature of the river has been transformed from a range of 0–30°C, to a cooler, narrower range of 7–12°C during 1974–2003, and 8–16°C after 2004;
- In cold mainstem conditions, Humpback Chub occupy areas adjacent to seasonally-warmed tributaries and mainstem habitat near warm springs;
- Starting in 2004, temperature of water released through Glen Canyon Dam increased in summer and fall to 16ºC; temperature increase enhances growth of Humpback Chub, but may also allow for invasion and expansion of warm-water nonnative fish species;
- Cold mainstem temperature has resulted in better adult body condition, lower incidence of parasites and diseases, greater longevity, and possibly faster recovery from spawning; and
- Reduced turbidity in the mainstem exposes the Humpback Chub to a higher risk of predation by sight feeders such as Rainbow Trout and Brown Trout.

Flow (Colorado River)—Flow of the Colorado River through the Grand Canyon has been altered by Glen Canyon Dam since 1963 (Figure 19). Spring peak flow at Lees Ferry (June) has decreased by ~80% from over 120,000 cfs to ~25,000 cfs, and base flow (January) has increased by ~67% from ~3,000 to 5,000 cfs (Figure 20).

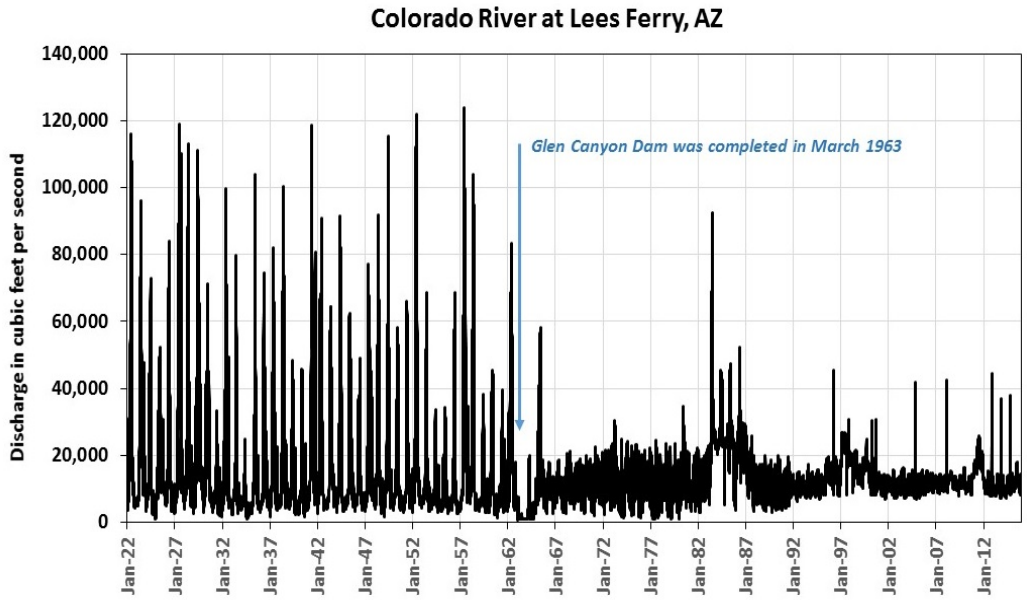


Figure 19. Mean daily discharge in cubic feet per second of the Colorado River at Lees Ferry (RM 0) before and after closure of Glen Canyon Dam, from 1922 to 2015. Glen Canyon Dam was completed in March 1963. Data from USGS site: Colorado River at Lees Ferry 09380000.

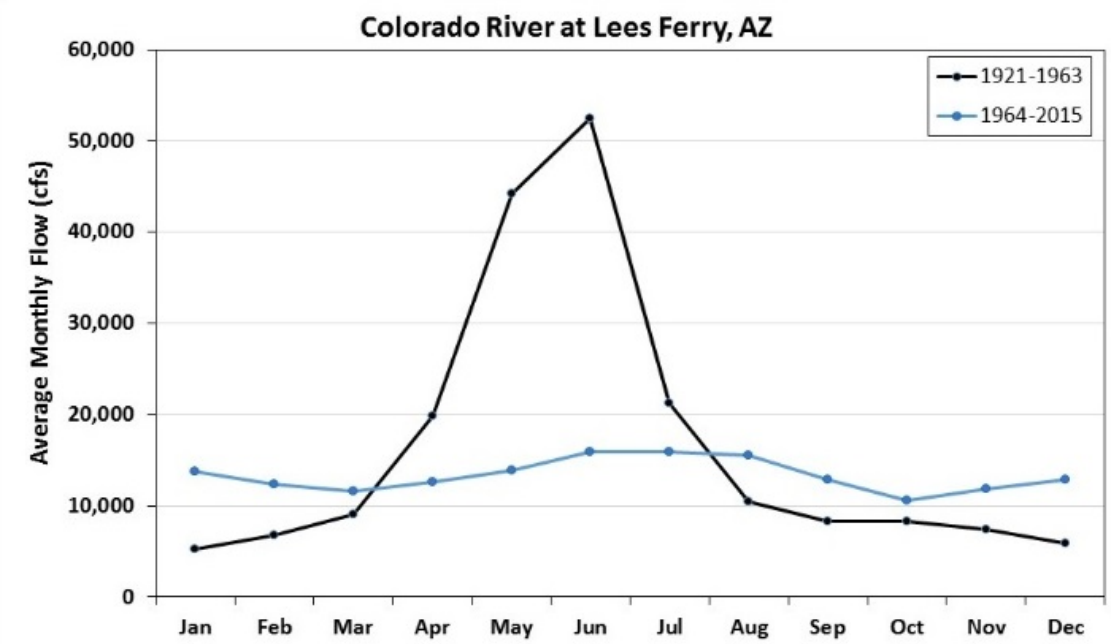


Figure 20. Mean monthly flows of the Colorado River at Lees Ferry for 1921–1963 (pre-Glen Canyon Dam) and 1964–2015 (post-Glen Canyon Dam). Data from USGS site: Colorado River at Lees Ferry 09380000.

Despite changes in flow and temperature, the Humpback Chub has continued to use the mainstem for all life stages, except spawning, egg incubation, and larval development, which take place mostly in the seasonally-warmed LCR. Adults use deep pools and recirculating eddies where food is entrained, and juveniles occupy a suite of shoreline habitats under the range of allowable flow change of up to 8,000 cfs per day (Converse et al. 1998; Korman et al. 2004).

Juveniles have shown no significant differences in survival or growth after 2 months of approximately steady fall flows, compared to daily fluctuations (Finch 2012). Adults appear to adjust to changing flows under large controlled floods of up to 45,000 cfs (Valdez and Hoffnagle 1999), and move freely to and from spawning sites under varying flows (Valdez and Ryel 1995), among mainstem aggregations and tributaries (Paukert et al. 2006), and between large eddy complexes with low velocity for low-energy feeding (Gerig et al. 2014).

Temperature (Colorado River)—The Colorado River through the Grand Canyon is stenothermic and cold because of releases through Glen Canyon Dam from the hypolimnetic layer of Lake Powell (Gloss et al. 2005; Melis 2011). The temperature regime of the once seasonally-warmed river has been transformed from a range of 0°C to 30°C, to a much narrower range of 7°C to 12°C during 1974–2003, and 8°C to 16°C after 2004 (Figure 21). Prior to 2004, Humpback Chub in the mainstem occupied areas with seasonally-warmed tributaries and warm springs (Valdez and Ryel 1995), but after 2004, the fish are increasingly occupying areas with suitable rocky complex shoreline habitat (Persons et al. 2015).

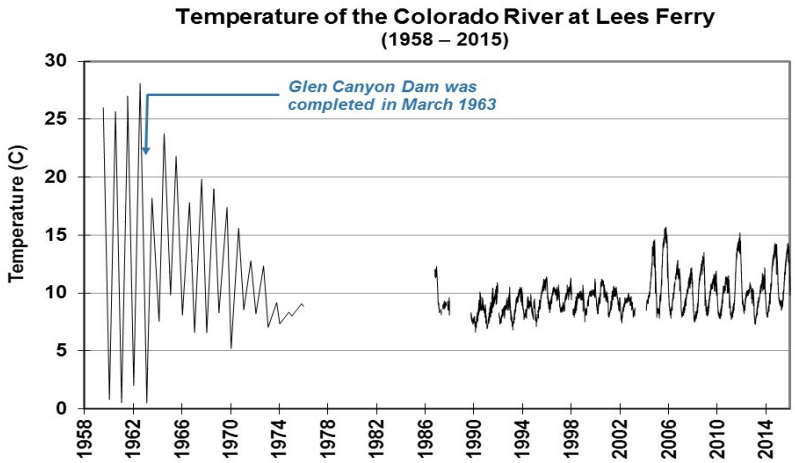


Figure 21. Temperature of the Colorado River at Lees Ferry before and after closure of Glen Canyon Dam, from 1958 to 2015. Glen Canyon Dam was completed in March 1963. Data from USGS site: Colorado River at Lees Ferry 09380000.

The Humpback Chub is an obligate warm-water species and although cold dam releases have impeded successful spawning in the mainstem, the species continues to live in the mainstem and use primarily the seasonally-warmed LCR for spawning, egg incubation, and larval development. Valdez and Ryel (1995) found a high proportion of adult Humpback Chub in the mainstem with spawning coloration and nuptial tubercles in May and June, indicating that sexual development was taking place at about the same time as fish in the upper basin, despite the cold water temperature. Brizendine (2016) used ultrasonic imaging to determine that female Humpback Chub are able to produce eggs in the mainstem Colorado River and that internal egg development and egg production likely do not limit recruitment, but females may never experience the environmental trigger(s) for spawning.

Humpback Chub in the mainstem grow slower than in the LCR (Pine et al. 2017). At a mainstem temperature of 10°C, there is no growth of larvae (Robinson and Childs 2001), and a growth rate of only 2.3 mm/30 days for age-0, compared to 10.6 mm/30 days at 20°C in the seasonally-warmed LCR (Lupher and Clarkson 1994; Clarkson and Childs 2000). Warmer water in Grand Canyon may increase Humpback Chub growth while limiting Rainbow Trout growth and thus reduce the number of days that juvenile Humpback Chub are vulnerable to predation by Rainbow Trout (Paukert and Petersen 2007).

The cold mainstem slows fish growth, but may also promote longevity. Humpback Chub that rear in the mainstem live ~5 times longer than fish in the LCR, but may take more than twice as long to reach adulthood and are ~40% less likely to survive to adults (Yackulic et al. 2014). Although fish in the Grand Canyon may live up to 40 years with greater spawning opportunity, the reduced survival rate may offset any benefit to reproductive potential. Conversely, fish that are life-long residents of the LCR grow quickly to adulthood (3–4 years) and have shorter life expectancies as adults (<20 years).

The current temperature regime of the Colorado River in the Grand Canyon may provide an overall benefit to the Humpback Chub. The cold water provides adults with better body condition (Meretsky et al. 2000; Didenko et al. 2004), a lower incidence of parasites and diseases (Hoffnagle et al. 2006), greater longevity, and possibly faster recovery from spawning (Yackulic et al. 2014). The present condition of Humpback Chub in Grand Canyon may be lower than previously reported in 2000, possibly because increased numbers of fish may be limiting space and food (Dzul et al. 2017).

Starting in 2004, the temperature of water released through Glen Canyon Dam increased in summer and fall when lower levels in Lake Powell allowed warm surface water to be entrained in the penstocks. Warmer releases of up to 16°C were reported in late summer and fall through 2015, but the magnitude and duration of these warm water releases have varied by year. This temperature increase has enhanced the growth of Humpback Chub in Grand Canyon and allowed greater mainstem residence and possibly reproduction in western Grand Canyon (Kegerries et al. 2016; Rogowski et al. 2017). The warmer temperature may also allow for expansion of warm-water nonnative fish species.

Pine et al. (2017) found biologically important differences in growth of Humpback Chub in the Grand Canyon for the 1980–1998 epoch (1), compared to the 2001–2011 epoch (2); slower growth occurred in the Colorado River in epoch 1 than in epoch 2 (because of higher reservoir levels and colder releases in epoch 1), and there was slower growth in the Colorado River compared with the Little Colorado River for all time periods. However, Hayes et al. (2017) and Finch et al. (2015) found slower growth of juvenile Humpback Chub in the Colorado River for the warm year of 2011 compared to epoch 1, and attributed the different to food limitation in 2011.

Turbidity (Colorado River)—Water turbidity is identified as cover for Humpback Chub from predators and for safe movement and feeding. The species is adapted to high turbidity, and relies on sporadic floods to deliver food and on the associated turbidity for cover while feeding. But the species also moves more frequently and greater distances under low light conditions, such as during crepuscular periods or at night (Valdez and Ryel 1995). This adaptation may be in response to the nearly constant historical turbidity, or to a more recent learned behavior to escape sight predators.

The historically turbid Colorado River in Grand Canyon was transformed into a river with high water clarity after completion of Glen Canyon Dam in 1963 (Figure 22). Virtually all of the sediment carried by the river settles to the bottom of Lake Powell and the only source of sediment is tributaries within the canyon, primarily the Paria River and the LCR (Melis 2011). Lower sediment budget and reduced turbidity in the mainstem expose the Humpback Chub to a higher risk of predation by sight feeders such as Rainbow Trout and Brown Trout (Valdez and Ryel 1995; Yard et al. 2011; Ward and Morton-Starner 2015).

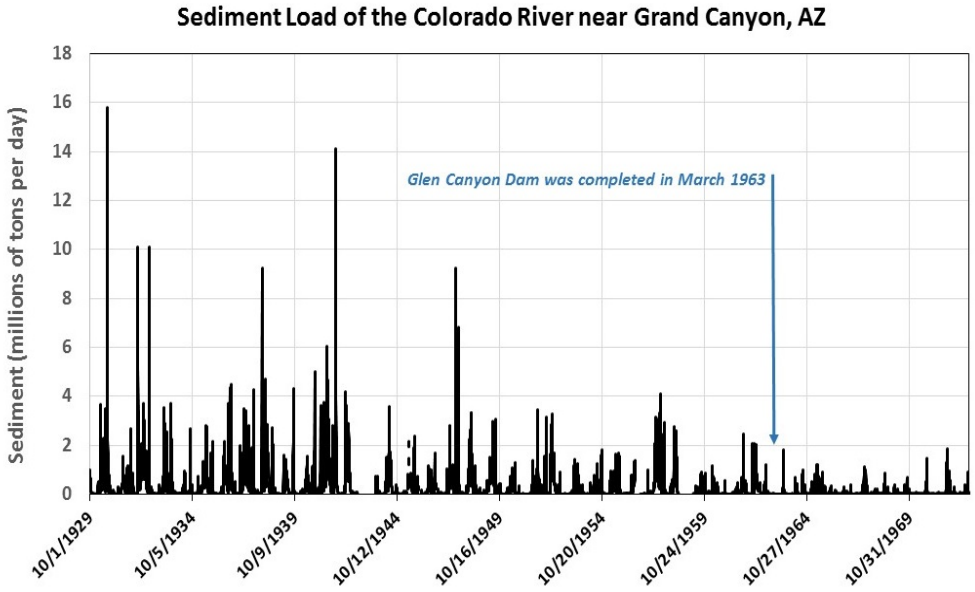


Figure 22. Sediment load of the Colorado River near Grand Canyon, AZ, before and after closure of Glen Canyon Dam, October 1, 1929 to September 30, 1972. Glen Canyon Dam was completed in March 1963. Data from Colorado River near Grand Canyon (09402500).

Flow (Little Colorado River)—The Little Colorado River is an important stream for the Humpback Chub in the Grand Canyon. The lower 12.9 km (8 miles) is designated critical habitat, and is the principal spawning area for the species in the Grand Canyon. The LCR provides habitat and food for the core population of the Grand Canyon. Although many young chub descend to the mainstem, there is a resident group of fish that spends their entire lives in the LCR (Yackulic et al. 2014).

The LCR was once a perennial stream throughout its course, except in years of severe drought (Morgan 1995). The Humpback Chub and other river fish once had access to the LCR up to Grand Falls, over 160 km upstream from the confluence of the Colorado River (Minckley 1973); the holotype for the Bonytail (*Gila elegans*; Girard 1856) is from the Zuni River, a tributary of the Little Colorado River in New Mexico, well upstream of Grand Falls. Apparently, at very high flows, fish from the mainstem Colorado River, including the Humpback Chub, could have historically accessed most of the LCR and its tributaries.

Dams and water depletions for municipal, agricultural, and industrial uses have transformed the LCR into an intermittent and highly variable stream with perennial flow only in the upper reaches of the watershed and in the lower 21 km below the Blue Springs complex. During much of the year, there is no surface flow in the middle and lower LCR above Blue Springs. Mean annual discharge of the LCR above Blue Springs is 219 cfs, as measured near Cameron (U.S. Geological Survey [USGS] Station 09402000, 1948–2007), but the flow is intermittent and varies considerably within and between years. Snowmelt runoff from the San Francisco Plateau and the Mogollon Slope in the southern portion of the watershed provides the

majority of surface flow in spring. The maximum instantaneous flow of 119,913 cfs occurred in spring 1954 (Hereford 1984), and the highest mean daily discharge of 18,400 cfs occurred in October of 1972 (USGS Station 09402000, 1948–2007) as a result of an early winter storm.

Periodic high flows serve to scour the LCR of accumulated sediment and to break up some of the travertine that builds up over time as a result of the calcium carbonate precipitate characteristic of the stream. Strong year classes of Humpback Chub have been related to high spring flow in the LCR, indicating that high flows cleanse marl, sediment, and precipitate from the system, stimulate food production, and enhance survival of eggs and larvae (Gorman and Stone 1999). In recent years, the mean daily discharge of the LCR has continued to decline after 1978 (Figure 23). Both the base flow provided by Blue Spring, and the periodic high spring flows provided by snow-melt runoff are important in maintaining suitable spawning condition for Humpback Chub in the LCR.

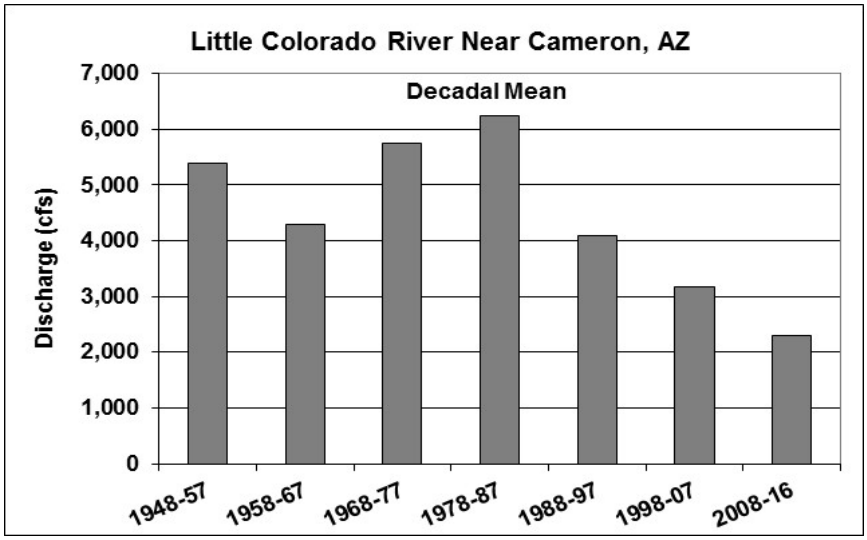


Figure 23. Mean daily discharge by decade of the Little Colorado River near Cameron, AZ, 1948–2007. Data from Little Colorado River near Cameron (USGS 09402000).

The Humpback Chub in the lower LCR is entirely reliant on flow from the Blue Springs complex for base flow, when there is otherwise no surface flow. Approximately 90% of the discharge for Blue Springs is from springs located between 16 and 21 km upstream of the confluence with the Colorado River (Cooley 1976). Flow volume of the Blue Springs complex has remained relatively constant during the last six decades. Cooley (1976), using data from Johnson and Sanderson (1968), reported an average discharge of 223 cfs for the period 1950–67, while Arizona Department of Water Resources reported 101,000 gallons-per-minute (226 cfs) between 1950 and 1993 (ADWR 2009b). A more recent estimate of discharge for Blue Springs is 237 cfs (Hart et al. 2002). The disparity in flow is unexplained and possibly related to measurement error or variation in spring discharge and not to human influence.

Over 99% of the Blue Springs complex discharges from a multiple aquifer system within the Redwall and Muav Limestones coming primarily from the Coconino (C) aquifer, a large underground aquifer that underlies much of the LCR Basin (Cooley 1976). In the area of the LCR canyon, the Coconino aquifer drains downward into the Redwall-Muav (R) aquifer via fractures through the Coconino, Hermit, and Supai formations. Once reaching the Redwall and Muav limestones, the water moves through solution channels and along fractures (Cooley 1976; ; Bills et al. 2016). Water issuing from the Redwall Limestone discharges primarily into Blue Springs in the lower LCR and into Havasu Springs in Havasu Creek, along with a few smaller springs and seeps arising along the south rim of the Grand Canyon.

The Coconino aquifer underlies ~14 million acres of the LCR Basin, and regional contributions from the aquifer to the Blue Springs complex vary. The Blue Springs area is considered the primary groundwater drain from the Little Colorado River Basin, although the primary source of the water is not well known (Hart et al. 2002; ADWR 2009b). The San Francisco volcanic field is able to contribute more of the water discharged at the Blue Springs complex than the eastern portion of the basin because of much higher precipitation and recharge rates, and because of secondary permeability imparted by the many faults and fractures in the area.

The aquifer that discharges water to the Blue Springs complex is coming under increasing demand. There is a considerable amount of groundwater pumping that draws water from the Coconino aquifer, and this pumping could affect the flow of the Blue Springs complex and reduce flow in the lower 18 km of the LCR that is currently a critical component of Humpback Chub habitat in the Grand Canyon. A similar reduction in discharge could occur in Havasu Springs that could result in reduced habitat in Havasu Creek, the location of a recent successful translocation of Humpback Chub. Effects of groundwater reduction in the Coconino aquifer may not be easily or immediately detected because of the slow response at Blue Springs, due to the large distance between areas of greatest recharge at high elevation and the Colorado River, as well as the relatively large storage and low transmissive of the aquifer (Pool et al. 2011).

Water emitting from Blue Springs is highly mineralized with sodium, calcium, chloride, and bicarbonate salts. The spring has a total dissolved solids (TDS) of 3,960 mg/L, with chloride composing 1,910 mg/L (Johnson and Sanderson 1968). The combination of these minerals imparts a milky blue or turquoise color to the water at base flow. Water from Blue Springs is 20°C and has a high free carbon dioxide (CO_2) level of 571 mg/L (Robinson et al. 1995), which precludes fish from using the area near the springs. As the water flows downstream, carbon dioxide gases dissipate into the atmosphere and calcium carbonate (calcite) precipitates as tufa, forming small travertine dams (Robinson et al. 1995). The calcite precipitate increases turbidity, imparts a milky color to the water, and covers the stream bottom with a layer of unconsolidated whitish particles. The Humpback Chub is among the few fish species able to live and reproduce in the water of the LCR and Havasu Creek; other

species that are predators or competitors (e.g., Channel Catfish, Rainbow Trout, and Brown Trout) live in these tributaries, but in small numbers with little or no reproduction.

The adaptability of the Humpback Chub to varied and rigorous environments and the species' ability to transition at will between the seasonally-warmed LCR and the colder, less saline Colorado River is on full display in the Grand Canyon. The species is able to carry out all of its life functions in water with a flow range of 237–120,000 cfs, a temperature range of 8–25°C, a TDS concentration of nearly 4,000 mg/L (seawater = 40,000 mg/L, brackish water = 10,000 mg/L), and a chloride concentration of nearly 2,000 mg/L (seawater = 18,980 mg/L). Adults have been observed spawning in the LCR at a flow range of 250–19,775 cfs, and individuals are able to persist during large floods with high sediments loads.

It is uncertain how or when continued pumping and withdrawal of water from the Coconino Aquifer will affect flow of the Blue Springs complex, but reduced base flow in the LCR could negatively affect the Humpback Chub through reduced stream capacity, spawning potential, survival, growth, and food production. Reduced base flow could also allow for a build-up of travertine in the LCR that could further reduce available space and habitat for the various life stages of the Humpback Chub.

Temperature (Little Colorado River)—The temperature of the LCR varies seasonally from a low of ~10ºC in winter to a high of ~25ºC in summer (Figure 24). This provides a seasonal temperature regime in which the Humpback Chub evolved with suitable spawning temperature in spring and summer for spawning, egg incubation, and larval development.

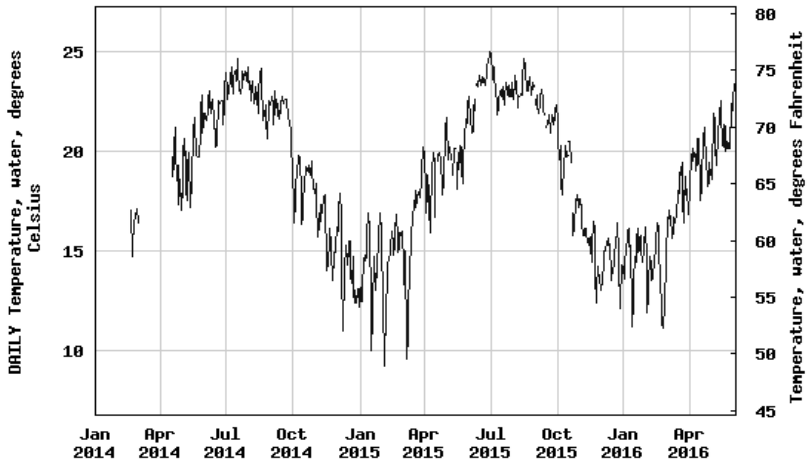


Figure 24. Mean daily temperature of the Little Colorado River above the mouth near Desert View, AZ, 2004–2016. Data from Little Colorado River above the mouth near Desert View (09402300).

Despite large changes in basin hydrology, the seasonal temperature regime and a steady base flow provided by the Blue Springs complex provide a stable and reliable habitat for the

Humpback Chub. Seasonal warming provides a cue for spawning, and the warm sheltered habitat of the LCR provides a food-rich environment for all ages of fish. This temperature regime is also suitable for completion of life cycles of many invertebrate species, especially insects such as blackflies and midges that are important food items for the Humpback Chub. Furthermore, the high TDS and chloride concentrations, combined with periodic scouring floods, provide a rigorous and arduous environment that otherwise disadvantages predaceous and competing nonnative fish species (Kaeding and Zimmerman 1983).

4.2.3 Adequate and Reliable Food Supply—The following is a summary of the food supply for the population of the lower basin followed by a detailed description:

- Starting in 1963, Glen Canyon Dam altered the flow, temperature, and sediment regimes of the Colorado River through Grand Canyon and transformed fundamental biological processes from a heterotrophic to an autotrophic system;
- The current aquatic community in the Lees Ferry reach (0–25 km below dam) is based on high water clarity and photosynthetic production that supports algal species (*Cladophora* and *Oscillatoria*) and a low diversity of cold-adapted invertebrates species; water clarity, photosynthesis, and invertebrate density decrease with distance downstream and turbidity increases from tributaries;
- Invertebrate drift concentration in the Lees Ferry reach is controlled by discharge and benthic density;
- The strong longitudinal pattern of food-web characteristics correlates with the spatial position of large tributaries and with evidence of intense fish competition for food with distance downstream from the dam;
- Food supply in the LCR is seasonally limited, but is in greatest abundance in April and May;
- Humpback Chub are piscivorous and cannibalistic at high density in the LCR; and
- The aquatic food base in Grand Canyon is affected by temperature, daily flow variation, and fish competition, all of which may limit the size of the Humpback Chub population.

There are few published reports on the pre-dam primary biological characteristics of the Colorado River through the Grand Canyon. Woodbury (1959) reported that the river through Glen Canyon was turbid much of the year from torrential floods, but was nearly clear during late summer low flows, suggesting that river productivity was primarily heterotrophic, but that some autotrophic photosynthesis was possible. Most of the pre-dam surveys of algae, diatoms, and invertebrates were species identification lists from tributaries, with no measure of standing biomass from the mainstem. The only study from the Colorado River System was before and after closure of Flaming Gorge Dam on the Green River of the upper basin (Pearson 1967); a river reach that is located at higher elevation than Glen Canyon Dam, and where allochthonous input is not as great and species composition is different.

A better assessment of the pre-dam condition can be gleaned from a study by Haden et al. (2003) of the benthic community structure of Cataract Canyon and the Green and Colorado rivers upstream of Lake Powell; this study provides a contemporary assessment that possibly reflects historical conditions in Grand Canyon. It shows that terrestrial organic matter is the primary energy source for aquatic invertebrates because high levels of suspended sediment inhibit algae growth. The invertebrate community is dominated by filter feeders (blackflies and caddisflies) and collectors (mayflies and midges), reflecting the importance of terrestrial organic matter. Prior to the closure of Glen Canyon Dam, the Colorado River contained large quantities of coarse woody debris (whole trees and branches) and other terrestrial plant material that was transported by landscape floods. This material accumulated in eddies and as huge driftwood piles along the river banks and supported an abundance of terrestrial insects that were also an important food source for fish in the Colorado River (Valdez and Carothers, 1998; Webb et al. 2002).

Numerous post-dam studies of the biological characteristics of the primary and secondary producer community of the Colorado River through Grand Canyon have been conducted and are summarized by Blinn and Cole (1991) and Kennedy and Gloss (2005). Generally, aquatic invertebrate diversity (the number of different species) declined following closure of Glen Canyon Dam, while invertebrate density and biomass increased in the Lees Ferry reach (Blinn and Cole 1991).

These studies describe the fundamental biological processes that were dramatically altered with the construction and operation of Glen Canyon Dam starting in 1963. The dam controls the flow of the river and releases cold water from the lowest layer of Lake Powell, and all sediment and organic matter being carried by the river settle in the reservoir. The altered flow regime, cold water temperature, and increased water clarity have transformed the biological processes of the river from a heterotrophic system, largely dependent on allochthonous carbon sources, to an autotrophic system with a high level of photosynthetic production and autochthonous carbon sources (Shannon et al. 1994; Kennedy and Gloss 2005; Vernieu et al. 2005).

These photosynthetic processes are reduced longitudinally downstream with increasing sediment brought in primarily by large tributaries. Stevens et al. (1997) found that *Cladophora* was the dominant algae from the dam to Lees Ferry with an average mass of 15.5 g C/m^2. Downstream of the Paria River, *Cladophora* standing mass decreased abruptly to 0.5 g C/m^2, and remained low to Diamond Creek. *Oscillatoria* spp., a mat-forming algae, dominated aquatic habitats downstream of Lees Ferry with average biomass of 0.6 g C/m^2 immediately downstream of the Paria River.

The species composition and biomass of aquatic invertebrates also varied with distance downstream during 1991. Stevens et al. (1997) found that the amphipod *Gammarus lacustris* and midges (Chironomidae) were the dominant aquatic invertebrates upstream of the Lees

Ferry reach, whereas, blackflies (Simulidae) were dominant downstream of the Paria River. They also found that invertebrate biomass declined in a downstream direction, with mean biomass of 2.9 g C/m^2 upstream of Lees Ferry and <0.1 g C/m^2 downstream. Hence, even though the Lees Ferry reach accounted for only ~7% of the aquatic habitat in the 390 km of river, it supported ~64% of the primary producer biomass and 87% of the invertebrate biomass. This downstream decline in productivity was attributed to decreased water clarity from tributary sediment input and to cold water temperature that precludes historical invertebrate species from becoming established.

Kennedy et al. (2013) showed that invertebrate drift concentrations in the Lees Ferry reach were jointly controlled by discharge and benthic densities operating at different timescales. They showed that a 2-fold variation in discharge associated with hydropeaking resulted in a >10-fold increase in drift concentration of benthic invertebrates associated with pools and detritus (i.e. *Gammarus lacustris* and New Zealand mudsnails). Conversely, drift concentration of sessile blackfly larvae that are associated with high-velocity cobble habitats, decreased by over 80% as discharge doubled, and was positively related to benthic density. This demonstrated that the propensity for insect taxa to drift and for non-insect taxa to avoid drifting probably underlies the structural changes in the invertebrate assemblage of the Colorado River after dam construction.

Dodrill et al. (2016) also found large differences in genus-level invertebrate richness for three western U.S. rivers. The Green River below Fontenelle Dam had a low hydropeaking index and the invertebrate assemblage was comprised of 54 unique genera, including many insects. The Green River below Flaming Gorge Dam had a moderate hydropeaking index and contained 47 unique genera; whereas the Colorado River below Glen Canyon Dam had a high hydropeaking index and supported only 12 unique genera, most of which are non-insects. Dodrill et al. (2016) found a virtual absence of EPT species (mayflies [E], stoneflies [P], and caddisflies [T]) in the Colorado River downstream of Glen Canyon, and suggested that hourly discharge variation from hydropeaking operations limits the success of aquatic egg-laying insect species whose eggs are desiccated during the incubation cycle.

Notably, several species of cold-tolerant nonnative invertebrates were intentionally introduced into the Colorado River after Glen Canyon Dam was closed in 1963. Altogether 10,000 immature mayflies were secured from a commercial source in Minnesota and released at three sites in the Lees Ferry reach. Also, 10,000 snails, 5,000 leeches, and thousands of insects representing at least 10 families were transported from the San Juan River in New Mexico to the river near Lees Ferry. In addition, 50,000 “scuds” (*Gammarus lacustris*) were introduced into Bright Angel Creek in 1932 and at Lees Ferry and below the dam in 1968, in addition to 2,000 crayfish taken from the LCR near Springerville, AZ (Blinn and Cole 1991). *Gammarus lacustris* has thrived in the cold, clear reaches below the dam, but the fate of the other introduced species is unknown.

Other nonnative invertebrate species have been found recently in the Grand Canyon, probably from incidental natural or human introductions, including the New Zealand mudsnail (*Potamopyrgus antipodarum*) and the red swamp crayfish (*Procambarus clarkii*). The quagga mussel (*Dreissena bugensis*) and Asiatic clam (*Corbicula* spp.) are abundant in Lake Powell and Lake Mead. Habitat in the Grand Canyon is unsuitable for the Asiatic clam, and is marginally suitable for the quagga mussel (Kennedy 2007), which has been found as one adult at RM 209 in April, 2015 (NPS unpublished data), and one adult near RM 60 (upstream of LCR confluence) in 2017 (USGS unpublished data).

Humpback Chub in the Colorado River through the Grand Canyon are typically omnivores, with a diet consisting of insects, crustaceans, plants, seeds, and occasionally small fish and reptiles (Valdez and Ryel 1995). Adults fed heavily on floating material entrained in eddies and low-velocity areas during an artificial flood in Grand Canyon, and the fish often feed on sporadic food supplies during large floods (Valdez and Hoffnagle 1999).

There is a strong longitudinal pattern in food-web characteristics that correlates with the spatial position of large tributaries, with evidence of intense competition for food with distance downstream from Glen Canyon Dam (Cross et al. 2013). Food supply in the LCR appears to be seasonally limited with greatest abundance in April and May; declining food supply after May could contribute to the age-0 fish descending from the LCR to the mainstem. During high densities in the LCR, the Humpback Chub is known to be cannibalistic, but the magnitude of piscivorous activity is unknown (Stone and Gorman 2006). Also, although Humpback Chub are omnivorous and may consume small fish on occasion, Spurgeon et al. (2015) found that translocated Humpback Chub in Shinumo Creek consumed fish as a large part of their diet.

Hayes et al. (2017) found that the juvenile Humpback Chub length–weight relationship during the warm-water period in 2011 did not differ from the relationship seen in the 1990s. In fact, at the larger fish sizes (> 150 mm TL), the predicted weight for a given length was lower in 2011 compared with several years in the early 1990s. These results were corroborated by Dodrill et al. (2014), who documented that Humpback Chub grew slower in 2011, despite the warmer water temperatures. This counterintuitive response indicates that Humpback Chub in Grand Canyon may be food-limited, even if optimal temperatures and more natural flows are experimentally provided.

4.2.4 Habitat With Few Nonnative Predators and Competitors—The following is a summary of predators and competitors in the population of the lower basin followed by a detailed description:

- ~50 species of nonnative fish have been introduced into the lower basin in the last 100 years; of 24 species that have been reported in the Grand Canyon, 13 are considered principal predators and competitors;

- Principal predators of juvenile Humpback Chub in the LCR include Channel Catfish and Black Bullhead, and predators in the mainstem are primarily Rainbow Trout and Brown Trout;
- In the LCR, competition for sub-adult Humpback Chub is primarily over food and space with Channel Catfish, Common Carp, and Black Bullhead, as well native Flannelmouth Sucker and Bluehead Sucker; competition in the mainstem is primarily with Rainbow Trout over food, as there is a strong longitudinal pattern in food-web characteristics that correlates with spatial position of large tributaries;
- New species (e.g., Smallmouth Bass) and expansions of existing nonnative species (e.g., Green Sunfish, Brown Trout) continue to raise concerns over warmer dam releases and the potential for increases of these populations; and
- Nonnative fish management is ongoing in the Grand Canyon to reduce the impact of nonnative predators and competitors.

Nearly 70 species of nonnative fish have been introduced into the Colorado River System in the last 100 years, including ~50 in the lower basin. Lists and descriptions of these fishes can be found in Minckley (1991), Minckley and Deacon (1991), Valdez and Ryel (1995), and Pacey and Marsh (1998). Predation is a major threat to the Humpback Chub in the Grand Canyon—as in the upper basin. ~24 species of nonnative fishes commonly occupy habitat used by the Humpback Chub in Grand Canyon, with 13 considered the principal predators and competitors (Figure 25).

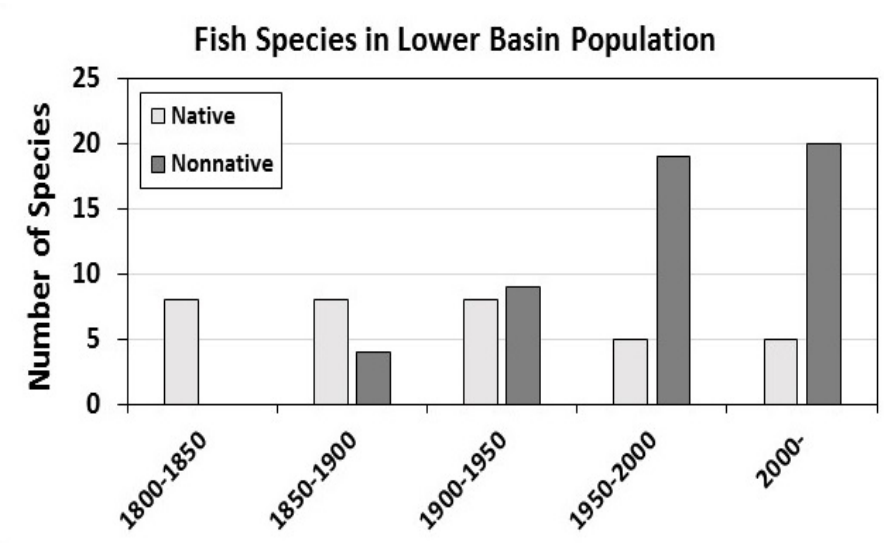


Figure 25. Numbers of native and nonnative fish species in the Humpback Chub population of the Grand Canyon.

Principal predators of juvenile Humpback Chub in the LCR include Channel Catfish and Black Bullhead (Marsh and Douglas 1997), and predators in the mainstem are primarily Rainbow Trout and Brown Trout (Yard et al. 2011). Valdez and Ryel (1995) surmised that

predation by Rainbow Trout and Brown Trout in the mainstem could lead to a complete loss of Humpback Chub year classes during cold dam releases, and Petersen and Paukert 2005 concluded that the window of vulnerability to predation in the mainstem would be shorter if warmer water temperature generated higher growth rates for juvenile Humpback Chub. Yard et al. (2011) determined that the incidence of predation by Brown Trout was higher (8–70%) than by Rainbow Trout (0.5–3.3%), but because the latter species is 50 times more abundant and consumes more fish (65% by Rainbow Trout and 35% by Brown Trout), the Rainbow Trout was considered the more significant predator. They also determined that Rainbow Trout and Brown Trout ingested 85% more native fish than nonnative fish despite native fish comprising less than 30% of small fish numbers.

Competition is also a threat from nonnative fish. In the LCR, competition for sub-adult Humpback Chub is primarily over food and space with Channel Catfish, Common Carp, and Black Bullhead, as well as native Flannelmouth Sucker, Speckled Dace, and Bluehead Sucker (Marsh and Douglas 1997). In the mainstem, competition is primarily with Rainbow Trout over food, as there is a strong longitudinal pattern in food-web characteristics that correlate with the spatial position of large tributaries (Cross et al. 2013). Invertebrate production declines ~18-fold below large tributaries while fish production remains similar to upstream sites and is predominately native fish taxa (80–100% of production). Many nonnative fish species occupy the same habitat as Humpback Chub in the Grand Canyon. These fish could increase in abundance with warmer dam releases, but of particular concern are highly predaceous species like Smallmouth Bass, Walleye, Channel Catfish, Green Sunfish, and Red Shiner. Actions to control the numbers of nonnative fish and to prevent expansion of invading species are ongoing and part of fish management in the Grand Canyon (see section 4.4).

4.2.5 Suitable Water Quality—The following is a summary of water quality in the population of the lower basin followed by a detailed description:

- Spring runoff in the LCR can transport a variety of municipal, agricultural, and industrial pollutants from the landscape that could detrimentally affect the principal spawning area of Humpback Chub in the Grand Canyon;
- The Arizona Department of Transportation completed a project in fall 2016 to replace the bridge at Cameron, AZ, substantially reducing the threat of accidental vehicle collisions and spills into the LCR that could reach critical habitat;
- Regional drought has led to a greater incidence of range fires and subsequent ash and debris-laden floods, such as those that killed and displaced a translocated group of Humpback Chub in Shinumo Creek in July and August 2014; and
- Water quality is not known to be limiting the Humpback Chub population in the Grand Canyon.

Water Quality and Contaminants—Water quality of the Colorado River through the Grand Canyon is determined largely by the water being released through Glen Canyon Dam and by tributary floods. No specific toxic materials or contaminants have been identified with detrimental effects to the Humpback Chub population. The cold stenothermic temperature has been identified as limiting mainstem life stages of warm-water native fishes, and changes in food-web dynamics in the Grand Canyon have been attributed to a reduction in nutrients that are largely retained in Lake Powell (Vernieu et al. 2005).

The biggest threat from water quality to Humpback Chub in the Grand Canyon is materials being washed from the landscape and down the LCR, where the majority of spawning takes place. The LCR has a base flow of ~237 cfs that originates from the Blue Springs complex ~20 km upstream from the mouth. Spring runoff in the LCR comes from a high elevation desert landscape with scattered towns and villages (ADWR 2009a) which can contain a variety of municipal, agricultural, and industrial pollutants. These contaminants tend to not reside long in the LCR and are flushed through and diluted in the mainstem Colorado River. There is no known detrimental effect of this seasonal flush of contaminants through the system.

Catastrophic Spills—Another major threat to water quality in the LCR is the possibility of an accidental spill of materials from an overturned truck at the U.S. Highway 89 Bridge at Cameron, AZ. This bridge is ~60 km upstream of designated critical habitat occupied by the Humpback Chub in the LCR. During much of the summer, the LCR is dry at Cameron, but substantial floods in spring and fall could quickly transport spilled material to habitat being used by spawning fish. Such a spill has never occurred, and fortunately, this threat has been reduced with replacement of the 58-year old 2-lane bridge with a 4-lane bridge by the Arizona Department of Transportation in fall 2016.[8] The project also constructed a roundabout at the intersection of US 89 and SR 64 to slow traffic in the Cameron area and to facilitate the flow of traffic. This construction should reduce the threat of accidental vehicle collisions and spills of materials into the LCR and substantially lessen this threat to the Humpback Chub.

Inflow of contaminants can also occur during a natural episodic event. Large floods and a large debris flow in Shinumo Creek in July and August 2014 killed or displaced a translocated population of Humpback Chub (Healy et al. 2014c). The physical scouring of the event and a dramatic geomorphic change in habitat, combined with a large volume of ash from a recent fire in the watershed, were probably the principal factors that eliminated most fish from the system, including Humpback Chub, Bluehead Sucker, Rainbow Trout, and Speckled Dace; a few Speckled Dace remained after the debris flow in isolated pockets. These floods entered the mainstem Colorado River where a large amount of debris and ash was reported, but with no detrimental effects (Emily Omana-Smith, National Park Service, Personal Communication, August, 2016).

[8] see: http://azdot.gov/projects/ north-central/us-89-cameron-roadway-improvements/overview

Water quality is not known to be limiting the Humpback Chub population in the Grand Canyon. Most water quality parameters are monitored in Lake Powell, through Grand Canyon, and in Lake Mead, and notable changes in a contaminant should be detected.

4.2.6 Unimpeded Range and Connectivity—The following is a summary of connectivity in the population of the lower basin followed by a detailed description:

- The population in Grand Canyon consists of a core population in and near the LCR and fish in the mainstem, including six aggregations located 41–90 km apart;
- There is no mainstem impediment to movement between Glen Canyon Dam and Hoover Dam; but there are chutes or small falls that impede movement ~14 km up the LCR, and in lower Shinumo Creek and Havasu Creek; Humpback Chub have been translocated above these barriers;
- Habitat appears to be expanding in western Grand Canyon with the receding level of Lake Mead and the ongoing carving of deltaic deposits in the lake inflow; these are exposing the original rock channel and enabling the species to reoccupy historical habitat;
- The Grand Canyon population is connected by movements of fish that augment existing aggregations and may populate unoccupied intervening areas; this movement is sufficient for genetic exchange, but the demographic effect is unclear; and
- At a species level, Glen Canyon Dam is a barrier to movement between the upper and lower basins.

The population of Humpback Chub in the Grand Canyon consists of a core population in and near the LCR and six aggregations located 124 to 368 km downstream of Glen Canyon Dam (Valdez and Ryel 1995; Persons et al. 2015). This population has been isolated from the five upper basin populations by the dam since 1963. The six aggregations are spaced 41, 69, 28, 43, and 90 km apart, with some movement of fish among aggregations and some fish occupying intervening areas.

The habitat of the Humpback Chub appears to be expanding in western Grand Canyon with the receding level of Lake Mead and the ongoing carving of deltaic deposits in the lake inflow, exposing the original rock channel and habitat historically occupied by the species (Bookstein et al. 1985). Surveys of western Grand Canyon (Diamond Creek to Pearce Ferry, RM 225-280), when the area was inundated by Lake Mead (Valdez 1992, 1994; Valdez et al. 1995), and as the river channel was being exposed by receding lake levels (Van Haverbeke et al. 2007), yielded fewer than 10 Humpback Chub. Recent small-fish sampling downstream of Lava Falls Rapid (RM 180) to Pearce Ferry (in the newly exposed river channel) yielded 18 and 67 larvae in 2014 and 2015, respectively (Albrecht et al. 2015; Kegerries et al. 2016).

Sampling by the Arizona Game and Fish Department (AGFD) with electrofishing (since 2000) and hoop nets (since 2016) has revealed densities of Humpback Chub in this lower reach comparable to and greater than areas traditionally considered aggregations (Rogowski et al. 2017). All age and size classes of Humpback Chub were represented below Diamond Creek with hoop nets in 2016, demonstrating that reproduction and recruitment occur in this reach. Only two of 145 fish captured below Diamond Creek were recaptures; whereas 50–80% of Humpback Chub in aggregations are recaptures (Persons et al. 2015). These tagging results indicate that Humpback Chub captured below Diamond Creek did not originate from the LCR or any of the identified aggregations, but are from local reproduction and recruitment. The presence of Humpback Chub and evidence of successful recruitment in western Grand Canyon has important implications as an extension of the core population, or possibly as a second reproducing population in the Grand Canyon.

Although most movement by Humpback Chub in the Grand Canyon is adults moving from the mainstem to spawn in the lower LCR (Yackulic et al. 2014), some fish move greater distances. Paukert et al. (2006) reported that two fish moved 52 km to and from the mainstem and the LCR within 1 year, and five fish moved 154 km to and from Havasu Creek and the LCR in a period of 2 to 5 years. Most extended movements are in a downstream direction with fish originating primarily in the LCR and moving to downstream mainstem aggregations (Valdez and Ryel 1995; Coggins 2008). This indicates that the Grand Canyon population is connected by movements of fish that augment existing aggregations, and this movement may serve to populate unoccupied habitats. The movement of individuals is certainly sufficient for genetic exchange, but the demographic effect is unclear.

Historically, Chute Falls (14.1 km up the LCR) was considered an impassible barrier to all upstream movement of Humpback Chub (Kaeding and Zimmerman 1983; Mattes 1993; Robinson et al. 1996). In 2007, 2009, and 2016, six Humpback Chub tagged below the falls were recaptured above the falls, confirming that at least small numbers of fish are able to move upstream to the area of the Blue Spring complex (Stone 2016). The Blue Springs complex, which is located ~20 km up the LCR is a chemical barrier to fish because of high carbon dioxide levels in the immediate vicinity of the springs (see section 4.2.2).

A steep chute falls at the mouth of Shinumo Creek blocks upstream movement of fish into that tributary, except at very high flows not currently seen in the Grand Canyon. A series of smaller chutes in lower Havasu Creek also impede fish movement into that tributary, except at high dam releases, such as during equalization flows and high-flow experiments. Juvenile Humpback Chub have been translocated from the LCR to each of these tributaries (see section 4.5.6), and the fish are currently showing signs of reproduction in Havasu Creek, but the fish were unfortunately killed or displaced by a series of large ash and debris-laden floods in Shinumo Creek.

4.2.7 Persistent populations—The following is a summary of the population in the lower basin followed by a detailed description (see section 4.5 for the demographic status of each population):

- The only population of Humpback Chub in the lower basin is in the Colorado River in Marble and Grand canyons, as well as the lower LCR and Havasu Creek;
- Since population estimates began in 1989, the number of adults in the LCR core population decreased by 54% from 10,946 in 1989 to 5,021 in 2001, and then increased by 52% from 5,021 to 7,650 in 2008; subsequent estimates using an alternative method that is not directly comparable are ~12,000 adults in 2012 (more recent estimates are not available); abundance estimates appear stable since 2009 (C. Yackulic, personal communication, 2017);
- There is evidence of successful spawning in Havasu Creek and at two additional mainstem locations (RM 30, RM 214);
- In addition to the core population in and near the LCR, ~250 adults and several hundred juveniles and sub-adults are distributed in ~408 km of the mainstem, with evidence of reproduction in western Grand Canyon; and
- The population of Humpback Chub in the Grand Canyon has undergone large changes, but is persistent as a core population with several mainstem aggregations and evidence of expansion in abundance and distribution.

The only population of Humpback Chub in the lower basin is in Marble and Grand canyons, with individuals occupying ~400 km of the mainstem Colorado River from RM 30 to RM 280, as well as ~18 km of the lower LCR and ~6 km of lower Havasu Creek. The core population (LCR population) includes fish from the LCR and fish in an area of ~15 km of the mainstem around the LCR confluence that move annually into the LCR to spawn and mix with resident fish (Kaeding and Zimmerman 1983; Valdez and Ryel 1995; Douglas and Marsh 1996). Most adults return to the mainstem after spawning, although some remain in the LCR for various periods of time (Yackulic et al. 2014).

Since population estimates began in 1989, the number of adults in the LCR core population decreased by 54% from 10,946 in 1989 to 5,021 in 2001, and then increased by 52% from 5,021 to 7,650 in 2008 (Coggins and Walters 2009). The average of 20 estimates for 1989–2008 is 7,080 adults. More recent estimates of adult abundance for 2009–2012 show a stable population of ~11,500–12,000 adults (Appendix S3 of Yackulic et al. 2014), and were developed using an alternative method that is not directly comparable to previous estimates.

In addition to the fish in and near the LCR, ~250 adults and several hundred juveniles and sub-adults occur in six mainstem aggregations distributed in ~295 km of the mainstem from RM 30 to RM 213 (Valdez and Ryel 1995); the numbers of individuals in these aggregations have been increasing since ~2014 (Persons et al. 2015). In 2015 and 2016, fish of all ages were also found in western Grand Canyon as far downstream as Pearce Ferry (RM 280;

Kegerries et al. 2016; Rogowski et al. 2017), which extends the current distribution of the species in Grand Canyon by ~108 km (67 mi).

Small numbers of fish move among the various mainstem aggregations (Paukert et al. 2006; Persons et al. 2015), and dispersal from the LCR may account for the fish in the lower canyon; however, spawning may be taking place in the lower canyon or in downstream tributaries, such as Havasu Creek (Nelson et al. 2016). Also, in 2014 a cohort of age-0 was detected near RM 214 (Pumpkin Springs aggregation), which could be followed into the age 1 and sub-adult size class during sampling in 2015 and 2016, respectively. Since 2014, ~345 Humpback Chub have been captured in hoopnets between Pumpkin Springs and Surprise Canyon, consisting of all size classes, and more juvenile Humpback Chub were captured with seines (Randy VanHaverbeke, U.S. Fish and Wildlife Service, Personal Communication, January 20, 2017).

4.2.8 High Genetic Diversity—The following is a summary of the genetic diversity of the population in the lower basin followed by a detailed description:

- Humpback Chub in the Grand Canyon are connected by gene flow with movement of fish within the mainstem and between the LCR and mainstem;
- Hybridization is not occurring in the Grand Canyon population because the Humpback Chub is the only *Gila* species remaining in the mainstem and lower end of tributaries;
- For a current population estimate of 9,000 to 12,000 adults associated with the LCR, genetic effective population is 899–1,437 adults; and
- A genetic analysis of fish from the LCR shows that the fish are genetically diverse with low and non-significant inbreeding coefficients, high levels of observed heterozygosity, and high allelic diversity.

The aggregations of Humpback Chub in the Grand Canyon are connected by gene flow with movement of fish among the LCR population and six aggregations. Surveys since the year 2000 (Rogowski et al. 2017) have revealed large numbers of Humpback Chub in western Grand Canyon (below Diamond Creek), but with few recaptured individuals, suggesting successful local reproduction. Neither Roundtail Chub nor Bonytail are present in areas occupied by the Grand Canyon population, and hybridization is not occurring. However, L msat analysis indicates evidence of historical hybridization with Bonytail haplotypes present in the 30-mile Marble Canyon aggregation (Douglas and Douglas 2007).

Genetic evidence of historical hybridization in the Grand Canyon is supported by collections of the three *Gila* species. In the 1940's, 5 Humpback Chub were collected from western Grand Canyon (at Lava Falls Rapid near Spencer Creek) along with 16 Bonytail and 6 Roundtail Chub (Miller 1944; Bookstein et al. 1985), indicating that the three species were historically sympatric in the Grand Canyon. The Roundtail Chub was common in the Glen

Canyon Dam tailwaters in 1967–1968, following dam closure (Stone and Rathbun 1968), but was probably locally extirpated by the cold dam releases and dramatic changes to the river ecosystem. The species is currently present in two tributaries of the upper LCR (Chevelon and East Clear creeks), but no individuals have been documented in the lower LCR or in the Grand Canyon since the 1960s.

The U.S. Fish and Wildlife Service has established a refuge population of ~1,000 adult Humpback Chub from the LCR at the Southwestern Native Aquatic Resources and Recovery Center (SNARRC) in Dexter, New Mexico. A genetic analysis of these fish shows that the fish are genetically diverse with low and non-significant inbreeding coefficients, high levels of observed heterozygosity, and high allelic diversity (Wilson 2014). A single sample estimate of the effective number of breeders (N_b, or the number of breeders in a single time period of one year) varied from 143 to 203, indicating the range in number of individuals that successfully spawn in the LCR each year. The effective population size (N_e) is a harmonic mean of 1,437 at a survival rate (S) of 0.87, and 899 at S of 0.82. This is the effective size of the population that contributes genetic information to the next generation and influences long-term genetic drift and evolutionary potential.

For a current population estimate of 9,000–12,000 adults associated with the LCR and an S of 0.87, the N_e/N_c is 0.12–0.16, whereas the N_e/N_c when S is 0.82 is 0.08–0.10 (Wilson 2014). Hence, at a higher survival rate of 0.87, between 12% and 16% of the adult population contribute genetic information to the next generation, and although the estimated LCR census size (N_c) is 9,000–12,000 adults, the effective population is comparable to a population of 899–1,437 adults, in terms of genetic drift (loss of allelic diversity), mutation (creation of new genetic diversity), and overall evolutionary potential. This appears to be a small proportion of the population and may be explained by low egg survival from rigorous water quality conditions in the LCR (see section 4.2.2) or by skipped spawning.

4.3 Current Condition of Species Needs by Population

The following is a summary of the current condition of species needs within each of the six Humpback Chub populations (Table 7):

1. **Black Rocks:** The physical habitat, temperature, food supply, and connectivity are in good condition. The population is small but dense (~400 Humpback chub / mile) persistent. Flows are altered, but are being managed and have improved since 1999 (date of the 15 Mile Reach PBO), and water quality does not appear to be detrimental. Removal of nonnative Smallmouth Bass, Walleye, Channel Catfish, Largemouth Bass in Black Rocks and adjacent areas upstream and downstream help to maintain low numbers of nonnatives (see section 4.1.4 and 4.4); despite occasional short-term increases in Largemouth and Smallmouth Bass densities within and near to Black Rocks, densities typically return to low levels within a few years. The most abundant species overall is the Roundtail Chub (44% to total numbers) that hybridizes and

competes with the Humpback Chub. Although genetic diversity is high in this population, introgressive hybridization is relatively high (Bohn and Wilson 2017) as Roundtail Chub move into this area in years of low spring flow (Francis et al. 2016). Despite periodic increases in nonnative fish densities, the large abundance of Roundtail Chub, and the small geographic scope of the habitat, Humpback Chub have persisted at this location since major changes (flow alteration and establishment of Channel Catfish) occurred more than 50 years ago.

2. **Westwater Canyon:** The condition of resources in Westwater Canyon is similar to the condition of nearby Black Rocks, including a similar composition of nonnative fish, primarily Channel Catfish, has remained static for more than 50 years. Despite occasional short-term increases in Largemouth and Smallmouth Bass densities within and near to Westwater Canyon, densities typically return to low levels within a few years. Control of nonnative fishes within Westwater Canyon, as well as areas upstream and downstream, also help to keep numbers low. The biggest difference between these proximate populations is that Westwater Canyon supports lower numbers of Roundtail Chub (26.5% in Westwater and 44% in Black Rocks). Evidence of hybridization is present in Westwater Canyon, and expansion of Roundtail Chub into this area also appears to be higher in years of low spring flow.

3. **Desolation/Gray canyons:** Desolation/Gray canyons are on the Green River, but resource conditions are similar for this population as for Black Rocks and Westwater Canyon on the Colorado River. Peak and base flows have improved since implementation of Muth et al. 2000, via Bureau of Reclamation Record of Decision in 2006. However, unlike populations on the Colorado River (Black Rocks, and Westwater and Cataract Canyons), the nonnative fish assemblage has changed in the past decade; a recent range expansion of Smallmouth Bass is concerning. Densities of Walleye and large Channel Catfish are low and Northern Pike are largely absent from this reach, but densities of Smallmouth Bass can reach elevated levels when upstream production is high. Smallmouth bass densities return to lower levels upon reduction of upstream production because of limited recruitment in the local area, but the species has apparently increased its established range with the canyon. Nonnative fish removal occurs within Desolation/Gray canyons, as well as areas upstream and downstream to keep the numbers of nonnative fish low. The Desolation/Gray canyons area has been subject to ash flows following range fires and to petroleum spills; these catastrophic events have been particularly stressful to the population as they often occur during low summer flows when water temperature is high and the river volume is low for dilution of contaminants.

4. **Cataract Canyon:** Resource conditions in Cataract Canyon appear to be good to moderate, as indicated for the three previously described populations. Flow management since 1999 on the Colorado River mainstem and since 2006 on the Green River have improved inter- and intra-annual flow variability, which we suspect improves conditions for Humpback Chub. Cataract Canyon is located downstream of

the confluence of the Colorado and Green rivers where high combined flows, arduous whitewater rapids, and few backwaters and sheltered habitats tend to reduce overall fish numbers. Nonnative fish in Cataract Canyon are dominated by Channel Catfish, Common Carp, Black Bullhead, Red Shiner, and Fathead Minnow, but this community composition has remained largely unchanged for many decades and Humpback Chub have persisted. Captures of Smallmouth Bass, Walleye, and Northern Pike within Cataract Canyon are very rare. The population of Humpback Chub in Cataract Canyon is small but persistent with probably fewer than 300 adults. The small size of this population raises concern over susceptibility to nonnative fishes moving up from Lake Powell and to long-term viability.

5. **Dinosaur National Monument:** Few Humpback Chub remain in the DNM population that includes the Yampa and Whirlpool Canyons. This population declined upon completion of Flaming Gorge Dam in the 1960s and has been tenuous since. The population is now considered functionally extirpated because Humpback Chub have not been collected in the Yampa River since 2004 (Finney 2006) and in the Green River since 2006 (Bestgen & Irving 2006).

   Population viability has been negatively impacted from multiple stressors, such as rotenone treatment in the Green River in 1962 (Holden 1991), cold hypolimnetic releases from Flaming Gorge Dam after 1963 (Holden and Crist 1981), expansion of nonnative fish (Haines et al. 2006), and exceptionally low Yampa River flows in the early 2000s. Dam penstock modifications in 1978 warmed releases and native fish have reinvaded historic habitat in the Green River above the Yampa River confluence, but not the Humpback Chub (Bestgen et al. 2006). Influxes of Smallmouth Bass occur when nearby production is high, but densities return to lower levels as nearby production is reduced. The habitat in DNM is otherwise suitable for Humpback Chub, but the number of fish is so low that intervention (e.g., fish translocation or stocking) will be necessary to restore this population.

   Native fish communities remain strong in both Yampa and Whirlpool canyons despite large densities of nonnative fish in nearby reaches, but lack Humpback Chub. The altered thermal regime in the Green River upstream of the confluence with the Yampa River precludes Humpback and Roundtail Chub from occupying this reach. Humpback Chub residing in DNM are therefore more reliant on Yampa Canyon and the natural thermal regime found there. However, summer base flows in Yampa Canyon are an order of magnitude lower than any other Upper Basin locations where Humpback Chub are found. Furthermore, in the early 2000's Yampa Canyon experienced brief periods of no surface flow. Since 2007, the UCRRP has augmented summer low flows in Yampa Canyon with a permanent pool (5,000 ac-ft) of fish water available in Elkhead Reservoir. The success of reestablishing a population of Humpback Chub in DNM will be dependent on the presence of adequate flow conditions.

6. **Grand Canyon:** Although the resources for this population have been altered by the construction and operation of Glen Canyon Dam, ongoing management is helping to maintain suitable habitat for the Humpback Chub and the species has shown a great deal of adaptability to a wide range of flow and temperature. The proportion of nonnative fish in Grand Canyon is among the lowest of the six populations (27%) and ongoing management actions help to prevent expansion of invading nonnative fish species (see section 4.2.4). The population increased from minimum levels observed in the early to mid-2000s and has been stable since 2008. The population appears to be continuing to expand in numbers and distribution in the mainstem into western Grand Canyon and from translocations to Havasu Creek and the LCR.

This assessment shows that species needs are generally in fair to poor condition for the six populations of Humpback Chub, and specific resources need ongoing management (river flow and nonnative fish, along with temperature and aquatic foodbase in the Grand Canyon). One population, DNM, will need intervention (translocation or stocking of fish) to restore the population.

River flow and predation/competition are the key factors controlling upper basin populations of Humpback Chub; whereas, river flow, water temperature, food supply, and predation/competition are the key factors controlling the lower basin population.

Table 7. A summary of the current condition of species needs for the six populations of the Humpback Chub. Color codes: dark green = resource condition is good; light green = resource condition is fair; yellow = resource condition is neutral; orange = resource condition is fair; red = resource condition is bad.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
1. Diverse rocky canyon river habitat	**Good** • Occupies 1.4 km of upper Colorado River on or adjacent to land managed by Bureau of Land Management and state of Colorado. • Regulations control access and use by rafters. • Some mining activity in area, but does not affect river channel. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat. • Physical habitat intact.	**Good** • Occupies 13.5 km of upper Colorado River on or adjacent to land managed by Bureau of Land Management and state of Utah. • Regulations control access and use by rafters. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat. • Physical habitat intact.	**Fair** • Occupies 75.8 km of Green River on or adjacent to land managed by Bureau of Land Management, Ute Tribe, and state of Utah. • Regulations control access and use by rafters. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat. • Physical habitat intact.	**Fair** • Occupies 25.6 km of upper Colorado River on or adjacent to land managed by Canyonlands National Park and state of Utah. • Regulations control access and use by rafters. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat. • Physical habitat intact.	**Fair** • Occupies 52.1 km of Yampa River and previously in 45.1 km of the Green River on or adjacent to land managed by Dinosaur National Monument and states of Colorado and Utah. • Regulations control access and use by rafters. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat. • Physical habitat intact.	**Good** • Occupies 405.5 km of Colorado River, lower 18 km of the Little Colorado River, and lower 5.6 km of Havasu Creek on or adjacent to lands managed by Glen Canyon National Recreation Area and Grand Canyon National Park, state of Arizona, Navajo Nation, Hopi Tribe, Hualapai Tribe, and Havasupai Tribe. • Regulations control access and use by rafters. • Encroachment by nonnative tamarisk in backwaters used by small numbers of native fish. • Physical habitat intact, except sediment managed by flow.
2a. Suitable flow	**Neutral/Ongoing Management** • Spring flow reduced by 33%, base flow increased by 37% since 1964. • Flow management since 2000 has restored important intra- and inter-annual variability. • Little additional flow alteration in last 20 years, but recent and ongoing drought has contributed to flow reduction.	**Neutral/Ongoing Management** • Spring flow reduced by 33%, base flow increased by 37% since 1964. • Flow management since 2000 has restored important intra- and inter-annual variability. • Little additional flow alteration in last 20 years, but recent and ongoing drought has contributed to flow reduction.	**Neutral/Ongoing Management** • Spring flow reduced by 34%, base flow increased by 76% since 1964. • Flow management since 2006 has restored important intra- and inter-annual variability. • Little additional flow alteration in last 20 years, but recent and ongoing drought has contributed to flow reduction.	**Neutral/Ongoing Management** • Spring flow reduced by 33-34%, base flow increased by 37–76% since 1964. • Flow management in Green (since 2006) and Colorado (since 2000) rivers has restored important intra- and inter-annual variability. • Little additional flow alteration in last 20 years, but recent and ongoing drought has contributed to flow reduction.	**Neutral/Ongoing Management** • Little flow regulation in Yampa River; flow regulated in Green River by Flaming Gorge Dam. • Since 2007, 5,000 ac-ft fish pool (with an option for an additional 2,000 ac-ft) available to augment base flows. • Flow reduction from recent and ongoing drought.	**Neutral/Ongoing Management** • Spring flow reduced by 80% and base flow increased by 67% since 1963. • Flow is determined by 2016 LTEMP EIS; Glen Canyon Dam releases designed to minimize impacts on canyon resources.
2b. Suitable temperature	**Fair** • Temperature of the upper Colorado River basin has increased 1.2°C in the 20th century, but effect of warmer water on Humpback Chub has not been measured.	**Fair** • Temperature of the upper Colorado River basin has increased 1.2°C in the 20th century, but effect of warmer water on Humpback Chub has not been measured.	**Fair** • Temperature of the upper Colorado River basin has increased 1.2°C in the 20th century, but effect of warmer water on Humpback Chub has not been measured.	**Fair** • Temperature of the upper Colorado River basin has increased 1.2°C in the 20th century, but effect of warmer water on Humpback Chub has not been measured.	**Fair** • Temperature of the upper Colorado River basin has increased 1.2°C in the 20th century, but effect of warmer water on Humpback Chub has not been measured.	**Fair** • Cold releases from Glen Canyon Dam are largely dependent on dam operations and Lake Powell elevation. • Warmer releases have occurred in fall since 2004 because of low reservoir elevation.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
3. Adequate and reliable food supply	**Fair** • Food is supplied by instream production of invertebrates, insect emergences, and floods laden with debris. • Food supply has not been measured, but is not believed to be altered.	**Fair** • Food is supplied by instream production of invertebrates, insect emergences, and floods laden with debris. • Food supply has not been measured, but is not believed to be altered.	**Fair** • Food is supplied by instream production of invertebrates, insect emergences, and floods laden with debris. • Food supply has not been measured, but is not believed to be altered.	**Fair** • Food is supplied by instream production of invertebrates, insect emergences, and floods laden with debris. • Food supply has been assessed and is not measurably altered.	**Fair** • Food is supplied by instream production of invertebrates, insect emergences, and floods laden with debris. • Aquatic diversity has been altered.	**Poor** • Aquatic insect diversity is low; productivity has declined, and is affecting fish condition. • Management effectiveness uncertain with studies ongoing to investigate instream production.
4. Habitat with few nonnative predators and competitors	**Fair/Ongoing Management** • 13 principal nonnative predators and competitors that may reduce survival of young and recruitment. • Nearby populations of Smallmouth Bass and Walleye have yet to colonize Black Rocks. • Increased Largemouth Bass catches in 2012 have declined to low numbers.	**Fair/Ongoing Management** • 13 principal nonnative predators and competitors that may reduce survival of young and recruitment. • Nearby populations of Smallmouth Bass and Walleye have yet to colonize Westwater Canyon.	**Neutral/Ongoing Management** • 11 principal nonnative predators and competitors that may reduce survival of young and recruitment. • Smallmouth Bass recently expanded range within the canyon. • Periodic increases in densities of Smallmouth Bass from upstream production, but recruitment is limited.	**Fair/Ongoing Management** • 13 principal nonnative predators and competitors that may reduce survival of young and recruitment. • Possible movement of some predators from Lake Powell through the canyon (e.g., Smallmouth Bass and Walleye) but these species have not colonized Cataract Canyon.	**Neutral/Ongoing Management** • 10 principal nonnative predators and competitors that may reduce survival of young and recruitment. • Periodic increases in densities of Smallmouth Bass from upstream and downstream production, but recruitment is limited. • Upstream production of Northern Pike supplies migrating adults. • Smallmouth Bass and Northern Pike have not colonized canyon habitats	**Neutral/Ongoing Management** • 13 principal nonnative predators and competitors; primary predators are Rainbow Trout and Brown Trout. • Increase of Brown Trout in Lees Ferry reach, causes(s) currently unknown but being investigated.
5. Suitable water quality	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • Railway adjacent to population poses threat of spill. • Petroleum pipelines in 100-year floodplain need shutoff valves.	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • Railway near population poses threat of spill. • Fish kill in 1989 from tributary flood laden with wild fire ash. • Petroleum pipelines in 100-year floodplain need shutoff valves.	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • Fish kill in 2012 from tributary flood laden wild fire ash. • Petroleum pipelines in 100-year floodplain need shutoff valves.	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • No known fish kills.	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • Fish kill in 1990s from oil pipeline rupture. • Petroleum pipelines in 100-year floodplain need shutoff valves.	**Neutral—Poorly Understood** • Variety of municipal, agricultural, and industrial contaminants, but effects not well understood. • Threat of contaminant spill at Cameron Bridge on Little Colorado River is reduced by recent bridge reconstruction. • Fish killed or displaced in Shinumo Creek in 2014 by ash-laden flood and debris flow from wild fire.
6. Unimpeded range and connectivity	**Fair** • No impediment for movement to other populations in upper basin. • Fish passage installed at Price-Stubb, Grand Valley, Government Highline, and Redlands diversions for upstream movement; small number of adults captured in fish passage.	**Fair** • No impediment to movement to other populations in upper basin. • Fish passage installed at Price-Stubb, Grand Valley, Government Highline, and Redlands diversion for upstream movement; small number of adults captured in fish passage.	**Fair** • No impediment to movement to other populations in upper basin. • Fish passage installed at Tusher Wash diversion for downstream movement; small number of adults detected in fish passage.	**Fair** • No impediment to movement to other populations in upper basin. • Fish passage installed at Price-Stubb, Grand Valley, Government Highline, Redlands, and Tusher Wash diversions for upstream movement; small number of adults detected in fish passage.	**Fair** • No impediment to movement to other populations in upper basin.	**Fair** • No impediment to movement in mainstem above Lake Mead. • Natural falls or chutes impede movement to upper Little Colorado River, and to lower Shinumo and Havasu creeks. • Successful translocations of young fish above these falls.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
7. Persistent populations	**Fair** • Population estimates declined from 880 in 1998 to 404 in 2012. • Annual reproduction and recruitment. • Four most recent estimates since 2007 indicate possible stabilization.	**Fair** • Population estimates declined from 3,520 in 1999 to 1,315 in 2012. • Annual reproduction and recruitment. • Four most recent estimates since 2007 indicate possible stabilization.	**Neutral** • Population estimates declined from 3,087 in 2001 to 1,672 in 2015. • Annual reproduction and recruitment. • Trend in adult abundance is statistically uncertain. • Less rigorous, catch-based monitoring over the past 30+ years starting in 1985 indicates potential stability.	**Neutral** • Adult numbers vary from 468 in 2003 to 295 in 2005; no recent estimates. • Apparent annual reproduction and recruitment. • Population has remained small but persistent since discovered in 1980. • Population trajectory is unknown.	**Bad** • Population is currently below detection limits and is now considered functionally extirpated. • Last collection of individuals in Yampa Canyon in 2004 and in Whirlpool Canyon in 2006. • Intervention in the form of translocations or hatchery stocking will be necessary to restore population.	**Fair** • Multistate model currently notes population at 12,000 in 2012. • Core Little Colorado River population appears to be stable, and fish in mainstem increasing in number and distribution. • Core Little Colorado River population is reproducing and recruiting annually. • Evidence of successful spawning in Havasu Creek and at two mainstem locations (RM 30, RM 214).
8. High genetic diversity	**Fair** • Black Rocks and Westwater populations are a subgroup of upper basin *Gila*, based on msat. • Exhibits highest level of introgression with Roundtail Chub. • Population is genetically diverse. • Genetic cluster may reflect spawning site fidelity and sites should be identified and protected.	**Fair** • Westwater and Black Rocks populations are a subgroup of upper basin *Gila*, based on msat. • Exhibits some level of introgression with Roundtail Chub. • Population is genetically diverse. • Genetic cluster may reflect spawning site fidelity and sites should be identified and protected.	**Fair** • A genetic subgroup of upper basin *Gila* separate from other subgroups and more similar to Roundtail Chub, based on msat. • Exhibits some level of introgression with Roundtail Chub. • Population is genetically diverse. • Genetic cluster may reflect spawning site fidelity and sites should be identified and protected.	**Fair** • A genetic subgroup of upper basin *Gila* closer to Desolation/Gray, based on msat. • Exhibits some level of introgression with Roundtail Chub. • Population is small but apparently genetically diverse. • Genetic cluster may reflect spawning site fidelity and sites should be identified and protected.	**Bad** • *Gila cypha* from Yampa Canyon is not genetically distinct, or may be absent, based on msat. • Evidence of hybridization with Roundtail Chub is high. • Population is functionally extirpated.	**Fair** • One subgroup of *Gila* for all Grand Canyon fish including aggregations, based on msat. • Population is genetically diverse with low and non-significant inbreeding coefficients, high levels of heterozygosity, and high allelic diversity. • Historic evidence of hybridization with Roundtail Chub and Bonytail, but no present introgression.

4.4 Ongoing Conservation Actions

The conditions of resources in the Colorado River System are managed through ongoing conservation actions designed to mitigate negative effects on the species. We consider these actions as part of the current condition of the resources because the ongoing conservation actions, and the programs that implement them, have been in place for decades. Three major programs in the Colorado River System are designed to balance demand for water, power, and recreation with protection of resources, including conservation of the Humpback Chub and other native species:

- The UCRRP coordinates recovery of the Humpback Chub, Colorado Pikeminnow, Razorback Sucker, and Bonytail upstream of Glen Canyon Dam;
- The Glen Canyon Dam Adaptive Management Program (GCDAMP) coordinates protection of natural resources of the Colorado River through the Grand Canyon, including the Humpback Chub and Razorback Sucker from Glen Canyon Dam to the Lake Mead inflow; and
- The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) coordinates conservation of multiple species, including the Humpback Chub, Razorback Sucker, and Bonytail downstream of the Lake Mead inflow.

The UCRRP, GCDAMP, and MSCP were established in 1988, 1997, and 2005, respectively, and have implemented a suite of actions that benefit a variety of species. These actions are necessary for ameliorating human effects as well as effects of reduced water availability, and help to conserve the suite of native species that inhabit this region of the Colorado River. The following is a summary of conservation actions implemented by these programs that address each of the species needs categories for the Humpback Chub (Table 9)

1. **Diverse rocky canyon river habitat:** The general provisions of all three programs, and the commitments by the stakeholders ensure protection of habitats occupied by the Humpback Chub and the lands surrounding those habitats. Habitats occupied by the Humpback Chub are under the management of the Bureau of Land Management (Black Rocks, Westwater Canyon, and Desolation/Gray canyons), Canyonlands National Park and Glen Canyon National Recreation Area (Cataract Canyon), DNM (Yampa Canyon), and Glen Canyon National Recreation Area, Grand Canyon National Park, the Hopi Tribe, Navajo Nation, Hualapai Tribe, and Havasupai Tribe (Grand Canyon), and the Ute Tribe (Desolation Canyon). The federal agencies are all under the Department of the Interior, and the Native American Tribes are stakeholders that have a significant role in these programs. Humpback Chub populations are in the states of Utah, Colorado, and Arizona, that also provide protection for these habitats.

2. **Suitable river flow and temperature:** Flow and temperature recommendations have been developed for the major rivers of the upper basin, and even more importantly these recommendations have been applied (see Table 4 above). Revised flow management provides Humpback Chub with more natural and consistent flow conditions, which is a great improvement from past decades, especially the early 2000 drought period. Recommendations are evaluated through a series of UCRRP studies that are coordinated through study plans. Technical committees evaluate each study and recommend further actions through the program's annual planning documents. In the Grand Canyon, Glen Canyon Dam releases are coordinated through operating criteria in the LTEMP EIS (U.S. Department of the Interior 2016) and in the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead EIS (U.S. Department of the Interior 2007).

   A temperature control device, installed on Flaming Gorge Dam in 1978, has warmed downstream releases for the Green River and allowed for upstream expansion of native fishes into Lodore Canyon (Bestgen et al. 2006). This warming could provide more suitable conditions for the reestablishment of the Humpback Chub population Whirlpool Canyon. In the lower basin, the Bureau of Reclamation has implemented feasibility studies for warming releases from Glen Canyon Dam. Warm releases from the dam starting in 2004 have provided insight to the possible beneficial effects of warming on native fishes in Grand Canyon, but warming could also benefit the nonnative fishes.

3. **Adequate and reliable food supply:** The general provisions of all three programs, including federal and state management actions help to protect the ecosystems of occupied habitats and surrounding lands. These provisions protect the health of the environment and promote production of invertebrates used as food by the Humpback Chub. In the Grand Canyon, where food supply has been altered, the LTEMP EIS includes studies to identify ways to improve the EPT populations (mayflies, stoneflies, caddisflies) through an evaluation of daily fluctuating dam releases.

4. **Habitat with few nonnative predators and competitors:** Predation and competition from nonnative fishes is one of the highest priority threats to the native fishes of the Colorado River System. As described in section 4.1.4, specific nonnative fish are of utmost management concern, and actions are being taken by each conservation program to control numbers of the most problematic species in both the upper and lower basins. Although Humpback Chub have no natural defense mechanisms, we propose that the harsh canyon habitats they inhabit are not as conducive to nonnative fish as the adjacent alluvial reaches.

   Upper Basin—The foundational document of the UCRRP recognized the threat and identified "Nonnative species and sportfishing management…" as one of five program elements to protect and recover the rare species in the upper basin (U.S.

Department of the Interior 1987). The UCRRP has implemented a number of plans and actions to manage nonnative fish, including the Nonnative Fish Management Policy, Integrated Stocking Plan, Yampa River Nonnative Fish Control Strategy, and upper Colorado River basin Nonnative and Invasive Aquatic Species Prevention and Control Strategy. The UCRRP and its partners currently remove problematic nonnative fish species from nine river reaches of the upper basin on the Yampa, Green, Colorado, White, Duchesne, and Gunnison rivers (Figure 26; Table 8). The species targeted for removal include: Smallmouth Bass, Northern Pike, Channel Catfish, Largemouth Bass, and Walleye, although other nonnative species are also removed as encountered. Additional projects are implemented at reservoir locations that contribute nonnative fish to downstream reaches. For FY 2017, the UCRRP spent ~41% of its $7 million annual operating budget on nonnative fish management.

Thorough scientific evaluations of the removal programs (e.g., Breton et al. 2014; Zelasko et al. 2014) guide implementation of removal activities, which currently focus on removing individuals from river habitats, disrupting in-river reproduction, and preventing escapement from upstream reservoirs. Removal efforts are adjusted annually to account for species ranges, densities, and environmental conditions. For example, in years with early onset of warm base flows, extra effort is applied to Smallmouth Bass removal, in order to limit production; similarly, as densities of Walleye increased in the late 2000s, extra effort was applied in target reaches, resulting in an apparent decline of Walleye catches by 2016 (Michaud et al. 2016).

Smallmouth Bass removal receives the highest effort in areas near Humpback Chub populations, such as Little Yampa Canyon upstream of the Dinosaur National Monument population; Walleye and Northern Pike are also removed at high rates in areas near Humpback Chub populations but are not found in high densities within the population areas (see section 4.1.4). Therefore, effort to remove these species within Humpback Chub habitats is reduced because densities are much lower. However, in years that densities are noticed to increase, commensurate increases in effort are applied. Nonnative fish are also removed duration population estimation work.

Nonnative fish in the upper Colorado River are removed primarily from the 106-km reach upstream of Black Rocks and Ruby-Horsethief Canyon (Loma, CO to Westwater Ranger Station, UT), where Smallmouth Bass production is highest; Smallmouth Bass, Largemouth Bass, Northern Pike have been removed from this area annually since 2004. Lower levels of removal take place downstream of Westwater Canyon and focus on Walleye. Removal of problematic nonnative fishes will continue in the areas adjacent to and in Black Rocks to thwart any sudden increase in numbers of nonnative fish that could be a threat to Humpback Chub.

In the Green River, nonnative fish are removed from Browns Park National Wildlife Refuge downstream to Canyonlands National Park, which includes Humpback chub

populations in Desolation\Gray canyons and Whirlpool Canyon (DNM population). Most effort is applied to Smallmouth Bass, especially in areas such as Island Park and the middle Green River, but specific efforts are also applied to Walleye, Northern Pike, and White Sucker. Large Channel Catfish are removed as part of other sampling efforts.

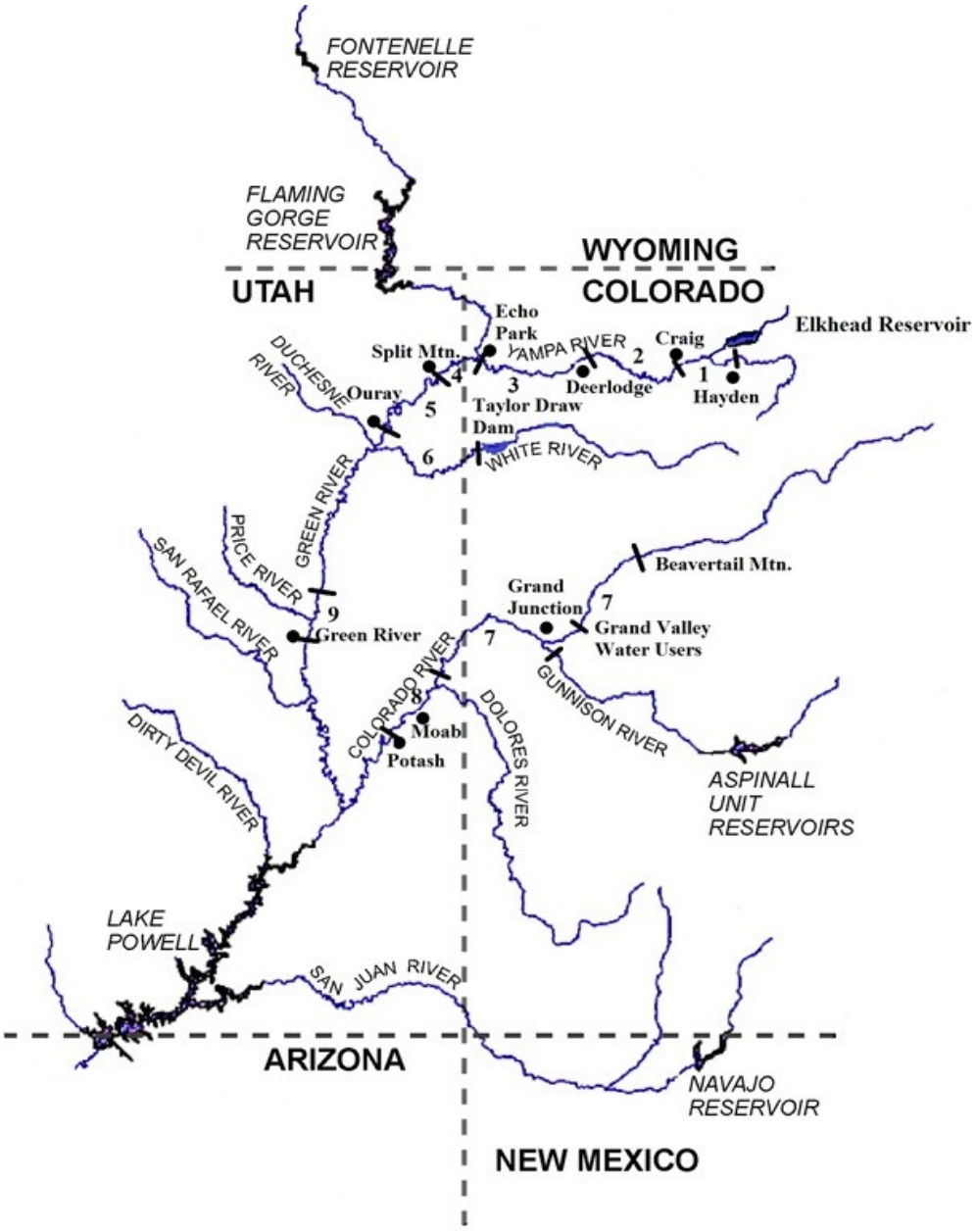


Figure 26. Reaches of the upper Colorado River basin from which target nonnative fish species are removed. Numbered reaches correspond to removal projects in Table 8.

Table 8. Ongoing projects of the Upper Colorado River Endangered Fish Recovery Program to reduce nonnative fish and sportfish impacts. Active removal projects are numbered and shown on Figure 26, as separate from research projects. Annual reports are available at: http://www.coloradoriverrecovery.org/documents-publications/work-plan-documents/project-annual-reports.html. NP = Northern Pike, SMB = Smallmouth Bass, WS = White Sucker, and WE = Walleye.

Project Name	River Reach	Purpose	Efficacy
1. Upper Yampa River Northern Pike Management	Yampa River: Hayden to Craig, CO (RM 160-151)	Remove NP, SMB, WS with multi-pass electrofishing and gill nets; 2005-2019	Reduce NP CPUE from 7.5 in 2005 to 2.6 in 2016
2. Middle Yampa River Northern Pike/Smallmouth Bass Management	Yampa River: Below Craig to Lily Park, CO (RM 134.2-50.5)	Remove NP and SMB with multi-pass electrofishing and gill nets; 2005-2017; includes a fishing tournament for SMB on Elkhead Reservoir	Adult NP and SMB CPUE reduced by >50% (2005 to 2016)
Supplement Middle Yampa River Smallmouth Bass and Northern Pike Management	Yampa River: Craig to DNM, CO (RM 151-47.5)	Remove NP and SMB with multi-pass electrofishing; 2008-2018	Reduce SMB abundance from 2418 in 2004 to 882 in 2016
Yampa River Fish Response	Little Yampa Canyon	Remove SMB from control and treatment reaches with electric seine; 2003-2018	Native fish abundance with removal of SMB from habitats
3. Lower Yampa River Nonnative Fish Management	Yampa Canyon (Deerlodge to Green River (RM 46-0)	Remove SMB with multi-pass electrofishing; 2004-2016	Reduce SMB CPUE from 21.6 fish/hr in 2004 to 8.62 in 2016
4. Green River Bass Management	Green River: Echo Park-Split Mtn. (RM 344.5-319.5) and DGC (RM 215.3-129.8)	Remove SMB with multi-pass electrofishing; 2004-2018	Reduce SMB CPUE in Echo to Split from 31.0 fish/hr in 2004 to 2.2 in 2016
5. Green River Bass Management	Green River: Split Mtn-Ouray (RM 344.5-207)	Remove SMB, NP, WE, WS with multi-pass electrofishing and fyke nets; 2010-2018	Adult SMB, NP, WE, WS CPUE reduced by >50% (2010 to 2016); periodic increases in young occur from reproductive success
Green River Fish Response	Middle Green River	Remove SMB and NP from control and treatment reaches with electrofishing; 2005-2011	CPUE of SMB and NP kept at low levels; project discontinued
Flaming Gorge Releases on Lodore/Whirlpool Fish Community	Green River: Lodore and Whirlpool canyons	To determine cumulative effect of flow and temperature regimes on SMB downstream of FGD; 2014-2018	Results being evaluated on effect of changes in flow and temperature on spawning SMB
6. Smallmouth Bass Control in White River	White River: Taylor Draw Dam to Green River confluence (RM 104.3-0)	Remove SMB with multi-pass electrofishing; 2012-2016	SMB CPUE reduced from 18.8 fish/hr in 2012 to 13.4 in 2016
7. Colorado River Smallmouth Bass Removal	upper Colorado River: Grand Valley Water User's (GVWU) dam, CO to Westwater UT; and Rifle to Beavertail Mountain, CO.	Remove SMB; 2004-2019	SMB CPUE reduced from 6.5 fish/hr in 2013 to 0.5 in 2016; periodic increases in young occur from reproductive success
8. Walleye Management	upper Colorado River: Cottonwood Wash below Westwater Canyon to Potash, UT (RM 112.3-47.2)	Remove WE and other problematic nonnative fish (e.g., SMB, NP, WS); 2014-2018	WE have been removed, but too soon to assess effect to numbers
9. Walleye Management	Green River: Tusher Diversion and Green River State Park (RM 128-120)	Remove WE and other problematic nonnative fish (e.g., SMB, NP, WS); 2014-2018	WE have been removed, but too soon to assess effect to numbers
Reservoir Management (various locations)	upper Colorado River basin	Nets and screens were installed to limit escapement of SMB, NP, and WE; In-reservoir removal; Harvest tournaments;	Limiting escapement from upstream reservoirs allows in-river removal to be more effective.
Population Dynamics Modeling, Smallmouth Bass	upper Colorado River basin	Assimilate database and develop a population dynamics model for SMB; 2009-2014	Population model developed for SMB to assess effect of SMB on native fish (Breton et al. 2015)
Population Dynamics, Northern Pike	Yampa River	Conduct comprehensive abundance and survival rate estimates for NP; 2011-2015	Estimates developed of abundance and survival of NP in Yampa River
Chemical Fingerprinting	upper Colorado River basin	Use strontium isotope signatures of otoliths to determine natal origins and hence, sources of invasion; 2006-2012	

In the Yampa River basin, Smallmouth Bass, Northern Pike, Channel Catfish, and Walleye removal takes place in Yampa Canyon. Nonnative fish removal is conducted at much higher levels upstream in locations like Little Yampa Canyon, Maybell, and Hayden to Craig. Northern Pike removal takes place upstream of Yampa Canyon as well, upstream as far as Steamboat Springs, Colorado.

Other basins, such as the Duchesne, White, and Gunnison rivers, receive nonnative fish removal effort as well. Despite having no Humpback Chub populations, removal in these reaches assists in basinwide control of these nonnative predators.

In addition to mechanical removal of nonnative fish in the upper basin, procedures for stocking nonnative fish have been developed under signed agreements between the U.S. Fish and Wildlife Service and the states of Colorado, Utah, and Wyoming that affect the Green River and upper Colorado River subbasins. These procedures identify the measures necessary to provide full evaluation of any species stocked in state waters and ensure that these introductions will not threaten native species.

Also, anti-escapement devices, such as downstream fish screens or in-reservoir nets, have been installed at the outlet of five small public reservoirs in the upper basin to reduce the numbers of nonnative fish that may escape to occupied habitat of native fishes.

The UCRRP is committed to applying a consistent, basin-wide nonnative fish management program that responds to annual conditions. For example, if increased densities of Smallmouth Bass are encountered in Desolation Canyon, or if flows will be conducive to their spawning, more effort will be applied in that location.

Lower Basin—A Nonnative Fish Control Environmental Assessment was implemented in the Grand Canyon in 2012 to help conserve native fish, particularly the Humpback Chub, by taking necessary actions to reduce numbers of nonnative fish, especially Rainbow Trout and Brown Trout in the Colorado River downstream of Glen Canyon Dam (U.S. Department of the Interior 2011). Efforts to mechanically remove nonnative fish were effective, but these target species recovered quickly after removal was suspended (Coggins 2008). The 2016 LTEMP EIS (U.S. Department of the Interior 2016) and the 2013 Comprehensive Fisheries Management Plan (National Park Service 2013) help to define future actions for controlling nonnative fish in the Grand Canyon. Although mechanical nonnative fish control strategies are in place in Grand Canyon, it is uncertain if mechanical removal in the mainstem Colorado River would be effective during large Rainbow Trout recruitment years, and/or if Brown Trout continue to increase in abundance in Glen Canyon and other areas and expand into the LCR inflow area.

Two major projects have removed large numbers of brown trout from the Grand Canyon in an attempt to evaluate the efficacy of a large scale non-native fish removal to benefit native fishes: (1) mainstem electrofishing in the vicinity of the LCR from 2003 to 2006, and (2) installation and operation of a fish weir to trap fish moving into and from Bright Angel Creek from 2006 to 2007 and 2010 to 2016.

During 2003-2006, over 23,000 nonnative fish, including rainbow trout (19,020; 82%) and brown trout (479; 1%), were removed from a 9.4-mile reach of the Colorado River near the LCR (Coggins 2008). These removals resulted in a rapid shift in fish community composition from one dominated by cold water salmonids (>90%), to one dominated by native fishes and the nonnative fathead minnow (>90%). Concurrent with the mechanical removal, data collected within a control reach of river suggested a systemic decline in rainbow trout unrelated to the fish removal effort. Thus, the efficacy of the mechanical removal was aided by an external systemic decline, particularly in 2005-2006. Subsequent sampling in the reach shows that the numbers of rainbow trout and brown trout was higher after increases starting in 2008, but these data sets may not be comparable after removal was suspended (Makinster et al. 2010).

The second effort to control nonnative fish, specifically brown trout, was implemented in 2006 in Bright Angel Creek. As recently as the 1970s, brown trout were rare in Bright Angel Creek (Carothers and Minckley 1981), despite this being one of the original stocking locations in 1926. After the 1990s, however, brown trout became a predominant component of the fish community in the creek, and a corresponding decline in native fish such as speckled dace was observed (Otis 1994). Bright Angel Creek is now a principal spawning site for brown trout, and a large aggregation is found in the Colorado River near the confluence with Bright Angel Creek (Valdez and Ryel 1995; Makinster et al. 2010).

In an attempt to restore the native fish community of Bright Angel Creek, and to reduce the threat of predation to Humpback Chub in the Colorado River, an ambitious program of mechanical removal of nonnative trout was implemented. In 2002–2003, a temporary weir was put in place that captured over 400 brown trout as part of a feasibility study (Leibfried et al. 2005; Figure 5). In 2006, the Bright Angel Creek Trout Reduction Project Environmental Assessment (EA) and Finding of No Significant Impact (FONSI; NPS 2006) identified goals and a strategy for reducing brown trout. This project was initiated in cooperation with the U.S. Fish and Wildlife Service in 2006-2007 (NPS 2006; Sponholtz et al. 2010) following the feasibility study conducted in 2002-2003 (Leibfried et al. 2005). This effort was resumed in 2010 (Trammell et al. 2012) following the 2008 and 2011 Biological Opinions on the Operation of Glen Canyon Dam that identified conservation measures to conduct trout reduction in Bright Angel Creek and to establish population redundancy of Humpback Chub in Grand Canyon tributaries (USFWS 2008, USFWS 2011).

Current operations under the Bright Angel Creek trout control project were established through the NPS Comprehensive Fisheries Management Plan (NPS 2013). From 2010-2012, trout reduction efforts included the installation and operation of a weir and backpack electrofishing the lower 2900 m of the creek (confluence to Phantom Creek; Trammell et al. 2012). Beginning in the fall of 2012, removal efforts were expanded to encompass the entire length of Bright Angel Creek (approximately 16 km) and Roaring Springs (approximately 1.5 km). The operation of the weir was also extended from October through February to capture greater temporal variability in the trout spawn (Trammell et al. 2012; NPS 2013). Removal efforts also occurred in the mainstem Colorado River near the Bright Angel Creek inflow in 2014 to 2016. This brown trout removal effort has continued annually from 2010 to 2017 (Schelly et al. 2017). There was also an increase in the number of Brown Trout in the Lees Ferry Reach starting in 2013, but a significant decline elsewhere in the mainstem (Rogowski et al. 2017). A special workgroup has been convened in 2017 to identify causes for expansion of Brown Trout and strategies for controlling numbers.

In the Grand Canyon, passage of nonnative fish from Lake Powell through the dam penstocks and generators has been identified by the Bureau of Reclamation as possibly increasing as reservoir elevation becomes lower and warm epilimnetic water is released through the dam. Coordinated removal of Green Sunfish, thought to have escaped through the dam, was conducted by the NPS, USGS, and AGFD in the Lees Ferry reach in 2016 and 2017, and the NPS remains vigilant to new species invasions and increases of existing species. Large numbers of Green Sunfish were discovered in a large isolated backwater in the Lees Ferry reach in 2015 and 2016. It is believed that these fish escaped through Glen Canyon Dam, and the National Park Service coordinated an interagency rapid response to remove the fish. The backwater or slough was treated with rotenone in November 2015[9], and with liquid ammonia in October 2016 (Ward 2016) and most of the fish were removed. Long-term strategies are described in a Comprehensive Fisheries Management Plan (National Park Service 2013) for dealing with these new invasions and expansions. Currently, nonnative fish in the Grand Canyon could potentially limit the Humpback Chub population, and resource management agencies are developing and implementing plans to control these species.

5. **Suitable water quality:** The states of the Colorado River System each have Hazardous Materials (HAZMAT) plans, but these have not been reviewed and evaluated to determine how to implement measures to mitigate contaminant spills in ways that protect the fish. Several pipelines are within the river floodplain, but these have not been identified and shut-off valves have not been installed. The Atlas Mills tailings continue to be removed from the Moab site. Some studies of selenium and

[9] see: https://www.nps.gov/glca/learn/news/Rapid-Response-Treatment-to-Remove-Invasive-Green-Sunfish-from-a-Backwater-Slough.htm

mercury effects on endangered fish have been done, but the effect of these elements on Humpback Chub remain uncertain. Selenium remediation has been implemented in the Gunnison River and sources of selenium have been tied to flow control in the Green River (e.g., Stewart Lake). In the lower basin, the bridge over the LCR and intersection of US 89 and SR 64 at Cameron, AZ was reconstructed in fall 2016, reducing the threat of hazardous materials spills reaching the principal spawning area of the Humpback Chub.

6. **Unimpeded range and connectivity:** Fish passage structures have been installed on all five water diversion structures in the upper basin on the Gunnison, upper Colorado, and Green rivers. These fish passages provide for upstream movement of fish and are either non-selective, where all fish are allowed to pass, or selective where nonnative fish are removed from the system and only native species are allowed to pass. These fish passage structures allow access by native fish to the more productive upstream reaches of historical range and could allow for population increases and expansions. Remote PIT-tag antennas at these fish passages have detected small numbers of tagged Humpback Chub moving upstream through these structures.

   In the lower basin there are no impediments to movement in the mainstem Colorado River above Lake Mead. Natural falls or chutes impede movement to the upper Little Colorado River, and to lower Shinumo and Havasu creeks. However, successful translocations have moved young fish above these falls. Glen Canyon Dam continues to be a barrier to mixing between the upper and lower basin.

7. **Persistent populations:** The upper basin populations of Humpback Chub are each monitored on a regular basis (2 consecutive years of 4) to estimate the numbers of adults and sub-adults, as well as recruitment and survival rates. Provisions have been put in place in the upper basin to minimize entrainment in canals and losses especially of young fish from populations. Fish screens or weir walls have been installed at the three canals in the upper basin on the Gunnison, upper Colorado, and Green rivers. These structures reduce losses of native fishes to canals where the water is released onto fields or the fish become stranded from seasonal drying.

   The lower basin population of Humpback Chub are monitored annually over the past three decades. The most recent modeling effort incorporates skip spawning behavior into a multistate model. The core Little Colorado River population appears to be stable, reproducing, and recruiting; fish in mainstem increasing in number and distribution. Evidence of successful spawning has been detected in Havasu Creek and at two mainstem locations (RM 30, RM 214).

8. **High genetic diversity:** Currently, no broodstock or refuge population of Humpback Chub from the upper basin exists in a hatchery facility, but a small number of adults from Black Rocks were taken to the Horsethief ponds near Grand Junction, CO,

where the fish have reproduced. Fish collected from the Yampa River and transferred to hatchery facilities turned out to be Roundtail Chub or hybrids. A refuge population of ~1,000 wild Humpback Chub, taken as young fish from the LCR, has been established at the Dexter SNARRC. Evaluation of these fish shows that they have high genetic diversity. A broodstock has not been established from these fish. Fish that are translocated in the Grand Canyon are captured as live, 2–4 month old fish, taken to SNARRC for grow-out, cleansed of parasites and diseases, and returned to Grand Canyon as PIT-tagged individuals. This strategy of using wild mixed fish ensures that genetic diversity is maintained throughout the canyon (Pine et al. 2013).

Table 9. Species needs categories, associated conservation actions, effect of actions, and benefit to the Humpback Chub.

Species Needs	Conservation Action	Effect of Action	Benefit to Humpback Chub
1. Diverse rocky canyon river habitat	Upper Basin: • Occupied habitats and surrounding lands are managed to conserve resources by BLM[a], CNP[b], DNM[c], GCNRA[d] and states of CO and UT.	Upper Basin: • Agencies regulate recreation and mining that protect habitat in the long term.	Upper Basin: • Occupied critical habitat is protected from direct human alteration.
	Lower Basin: • Occupied habitats and surrounding lands are managed to conserve resources by GCNRA, GCNP[e], and state of AZ, as well as the Hopi Tribe, Navajo Nation, Hualapai Tribe, and Havasupai Tribe.	Lower Basin: • Agencies regulate recreation and mining that protect habitat in the long-term.	Lower Basin: • Occupied critical habitat is protected from direct human alteration.
2. Suitable river flow & temperature	Upper Basin: • The Bureau of Reclamation and upper Colorado River basin water managers have changed their operations to achieve flow and temperature recommendations for the endangered fish in the Colorado River (Osmundson et al 1995; McAda 2003), Green River (Muth et al. 2000), and Yampa River (Roehm 2004; USFWS 2005a – See Table 4 for more detail). • In 2007, the Recovery Program secured a permanent source of summer augmentation water (5000 ac-ft with an option to lease an additional 2000 ac-ft) in Elkhead Reservoir in the upper Yampa River drainage. • Collaboration among UCRRP, Reclamation, and The Nature Conservancy to address reduced water availability.	Upper Basin: • Operations to meet flow and temperature recommendations benefit native chubs • Flow recommendations provide foundation to support life stages of Humpback Chub. • Ongoing and long term commitments to flow management improves habitat for various life stages of Humpback Chub. • Promotes concepts of the Natural Flow Paradigm (Poff et al. 1997) expected to favor native over nonnative species. • Provisions for reduced water availability help to address low stream flows. • Improve summer base flow conditions in the Yampa River.	Upper Basin: • High spring flows cleanse substrate of silts for successful spawning. High spring flows minimize invasion by hybridizing Roundtail Chub. • Increased magnitude and duration of the spring peaks reduces influxes of nonnative Smallmouth Bass. Adequate base flows provide swift current that minimizes Smallmouth Bass spawning habitat • Floods deliver organic matter for food production. • Reliable flows ensure habitat sustainability. • Flow management on the Yampa River could benefit a future Humpback Chub repatriation effort in DNM, deemed necessary. • Population response is uncertain and expected to take one or two generations to exhibit. Population estimates in 2018-2023 will determine if flow and temperature management is effective.
	Lower Basin: • LTEMP EIS for Operation of GCD[f] (U.S. Department of the Interior 2016) establishes flow regimes. • Bureau of Reclamation has implemented feasibility studies for warming releases from GCD as part of the LTEMP EIS. • MSCP Habitat Conservation Plan (U.S. Department of the Interior 2016).	Lower Basin: • GCD releases are designed to not adversely affect the Humpback Chub. • Warm releases from GCD starting in 2004 enable greater growth by Humpback Chub, but may allow for expansion of nonnative fish in the Grand Canyon. • MSCP funds help to evaluate Humpback Chub expansion into western Grand Canyon.	Lower Basin: • Moderate daily flow changes may improve aquatic insect production as food for fish. • High flow experiments help to maintain backwaters and stimulate primary production. • Warmer dam releases improve fish growth. • Possible future modifications to warm dam releases could allow for mainstem spawning.

Species Needs	Conservation Action	Effect of Action	Benefit to Humpback Chub
3. Adequate and reliable food supply	Upper Basin: • General provisions of all three programs and federal and state management ensure protection of occupied habitats and surrounding lands.	Upper Basin: • Food supply is protected with protection of occupied habitats and surrounding lands.	Upper Basin: • Sustained food supply is critical to growth and survival of young and for recruitment.
	Lower Basin: • LTEMP EIS includes studies to identify ways to improve food supply in the mainstem.	Lower Basin: • Studies are ongoing to evaluate EPT populations (mayflies, stoneflies, and caddisflies) and effect of daily fluctuating dam releases.	Lower Basin: Food supply in Grand Canyon may be limited and moderate daily flow changes may improve aquatic insect production.
4. Habitat with few nonnative predators and competitors	Upper Basin: • Thorough scientific evaluations of removal efforts guide implementation of field actions (Breton et al. 2014; Zelasko et al. 2014) to disrupt in-river reproduction and prevent reservoir escapement. • Nonnative fish removal efforts are ongoing in the Green, Yampa, and upper Colorado rivers (and other basins that do not contain Humpback Chub). • Upper Colorado River Basin Nonnative and Invasive Aquatic Species Prevention and Control Strategy completed (Martinez et al. 2014). • Procedures for stocking nonnative fish species in the upper Colorado River basin, revised (USFWS 2009c). • Fish screens to prevent escapement of nonnative fish. • Harvest regulations in the states of Utah and Colorado promote removal of nonnative species.	Upper Basin • Removal efforts have reduced numbers of nonnative fish, but some populations rebound when removal is suspended. • UDWR has a must kill policy on all Northern Pike, Walleye, Smallmouth Bass, and Burbot caught in the Green River; Colorado has unlimited catch regulations for the same species. • Fish screens have been installed at: Elkhead Reservoir (2007 and 2016, Yampa River), Starvation Reservoir (2015, Duchesne River), Rifle Gap Reservoir (2013, Rifle Creek, upper Colorado River), Highline Reservoir (1999, Mack Wash, upper Colorado River), Juniata Reservoir (Gunnison River), and various small riverside ponds near Grand Junction, CO.	Upper Basin • Reducing numbers of nonnative fish will improve survival of young, enhance recruitment, and increase population size and age structure. • Fewer nonnative fish will reduce competition with native fish over space and food. • Fewer nonnative fish will reduce species of parasites and diseases and incidence of infestation. • Population response is uncertain and is expected to take one or two generations to manifest. Population estimates in 2018-2023 will determine if nonnative and habitat management has resulted in population response.
	Lower Basin: • LTEMP EIS and Nonnative Fish Control EA. • Arizona Game Commission has implemented no fishing regulations for the area around the LCR to prevent incidental take of Humpback Chub. • Conservation Plan (LCR MSCP 2004) provides guidance for nonnative fish management in Lake Mead and western Grand Canyon. • State of Arizona currently has restrictions for stocking nonnative fish waters in and near the Grand Canyon. • Escape of nonnative fish from Lake Powell through the GCD penstocks and generators is being evaluated.	Lower Basin: • Removal of Rainbow Trout and Brown Trout has been implemented and evaluated. • Triggers have been developed in the LTEMP EIS to implement nonnative fish removal. • Restrictions to stocking nonnative fish will continue, but many nonnative fish species already occur. • Nonnative fish occur in Grand Canyon tributaries and in Lakes Powell and Mead, but no provisions are in place for exclusion devices or strategies. • Lower elevation of Lake Powell may lead to an increase in fish passing through the penstocks.	Lower Basin • Reducing numbers of nonnative fish will improve survival of young, enhance recruitment, and increase population size and age structure. • Fewer nonnative fish will reduce competition with native fish over space and food. • Fewer nonnative fish will reduce species of parasites and diseases and incidence of infestation.

Species Needs	Conservation Action	Effect of Action	Benefit to Humpback Chub
5. Suitable water quality	Upper Basin: • State HAZMAT plans have not been reviewed. • Pipeline crossings have not been identified and shutoff valves have not been installed. • Atlas Mills tailings continue to be removed. • Some studies of selenium and mercury effects on endangered fish completed, but effects remain uncertain. • Selenium remediation has been implemented in the Gunnison River and sources of selenium (e.g., Stewart Lake) have been tied to flow control.	Upper Basin: • Would prevent or reduce incidence of hazardous-materials spills. • Would reduce the amount of toxic spills. • Would remove toxic materials from the river bank. • Identifies primary sources of selenium • Determines concentrations in water and fish. • Identifies harmful concentrations.	Upper Basin: • Hazardous-materials spills can have catastrophic effects on populations by killing large numbers of fish, causing stress and disease, and eliminating entire year classes that result in failed recruitment and reduced population size. • Water contaminants can have insidious effects on fish physiology, including detrimental effects on reproduction, growth, and survival. • Selenium remediation helps to reduce selenium, which can negatively affect fish reproduction and survival.
	Lower Basin: • The bridge over the LCR and intersection of US 89 and SR 64 at Cameron, AZ has been reconstructed. • Arizona Department of Environmental Quality promotes and enforces clean water standards throughout the State, including the Grand Canyon.	Lower Basin: • Bridge reconstruction reduced the threat of a hazardous materials spill in the LCR that could reach the spawning area of the Humpback Chub. • Enforcement of clean water regulations help to reduce toxic contaminants.	Lower Basin: • Completion of the bridge and intersection at Cameron in fall 2016 has reduced the risk of a catastrophic spill that could kill large numbers of fish in the LCR. • Water contaminants can have insidious effects on fish physiology, including detrimental effects on reproduction, growth, and survival.
6. Unimpeded range and connectivity	Upper Basin: • Fish passage structures have been installed at Redlands Water and Power Company Diversion on the Gunnison River (1996); Grand Valley Irrigation Company Diversion (1998), Grand Valley Project Diversion (2005), and Price-Stubb Diversion on the upper Colorado River (2008); Craig Diversion on the Yampa River (1992); and Tusher Diversion on the Green River (2016).	Upper Basin: • Small numbers of Humpback Chub have been caught at fish passage structures in the upper basin indicating that the fish are free to move and possibly establish new populations or exchange with existing populations.	Upper Basin: • Unimpeded movement allows the fish to move among population for genetic exchange and maintain genetic diversity of populations. • Providing additional range could allow fish to move into unoccupied but suitable habitat and start new populations.
	Lower Basin • Fish passage has not been installed in Humpback Chub habitat of the lower basin, but wild fish have been translocated upstream of waterfall and chutes in the upper LCR, Shinumo Creek, and Havasu Creek.	Lower Basin: • Successful translocations of fish in Grand Canyon demonstrate the ability of the Humpback Chub to be moved and to adjust to new locations.	Lower Basin: • Unimpeded movement allows the fish to move among aggregations for genetic exchange to maintain genetic diversity, and for augmenting aggregations, and possibly to establish a mainstem population. • Translocating fish to tributaries provides additional groups of fish for redundancy and may lead to establishment of new populations that provide resiliency in case of a loss of other populations.

Species Needs	Conservation Action	Effect of Action	Benefit to Humpback Chub
7. Persistent populations	Upper Basin: • Populations are monitored on a regular basis to estimate the numbers of adults and sub-adults, as well as recruitment and survival rates. • Fish screens or weir walls have been installed to reduce entrainment at Redlands Water and Power Company Diversion (2005, Gunnison River); Grand Valley Irrigation Company Diversion (2002), Grand Valley Project Diversion (2006), Price-Stubb Diversion (2014, upper Colorado River), and Tusher Wash Diversion (Green River).	Upper Basin: • Annual population estimates are done for two consecutive years in every two years in Desolation/Gray, Westwater and Black Rocks. The Cataract population is monitored biennially by assessing long-term catch rate trends. • Fish screens and weir walls on canals reduces loss of fish through entrainment.	Upper Basin: • Monitoring the fish annually helps to assess population size and structure and to identify problems with decline of numbers. • Fish screens and weir walls will reduce loss of fish and enhance survival, recruitment, and population structure and size.
	Lower Basin: • The population and aggregations are monitored on a regular basis to estimate the numbers of adults and sub-adults, as well as recruitment and survival rates. • Escape of fish through the GCD penstocks has been evaluated (Hart and Sherman 1996; Reclamation 2012b)	Lower Basin: • Annual population estimates are done annually in the LCR and periodically in aggregations. • Some escape of nonnative fish is reported through GCD, but the effect to downstream fish has not been evaluated.	Lower Basin: • Monitoring the fish annually helps to assess population size and structure and to identify problems with decline of numbers. • Monitoring helps to identify new fish so that control measures can be implemented to reduce effects of predation and competition.
8. High genetic diversity	Upper Basin: • Initial genetics analysis completed (Douglas and Douglas 2007). • Fish collected from the Yampa River and transferred to hatchery facilities determine to be Roundtail Chub. • No upper basin Humpback Chub refuge population or broodstock currently exist.	Upper Basin: • Initial genetic analysis shows genetic diversity from decadal scale exchange of individuals among populations. • Humpback Chub are not currently being stocked in the upper basin.	Upper Basin: • Maintaining genetic diversity among upper basin populations is important to ensure that fish maintain adaptive traits for reproduction, growth, and survival. • Humpback Chub are not currently stocked in the upper basin, but stocking may be appropriate to return fish to historical habitat (e.g., Yampa and Whirlpool canyons) and to establish new populations in suitable habitat. • Reestablished and new populations will provide redundancy and resiliency.
	Lower Basin: • Conservation Plan (LCR MSCP 2004) provides guidance for stocking procedures for native fish in the lower basin. • Genetic evaluation has been done for refuge population from Grand Canyon (Wilson 2014) and for wild fish translocated in Grand Canyon. • Refuge population of ~2,000 fish currently at Dexter SNARRC.	Lower Basin: • Wild Humpback Chub may continue to be translocated in the Grand Canyon. • Humpback Chub are not currently being stocked by the MSCP.	Lower Basin: • Maintaining genetic diversity throughout Grand Canyon is important to ensure that fish maintain adaptive traits for reproduction, growth, and survival. • Translocated fish in historical habitat may help to establish new populations. • Reestablished and new populations will provide redundancy and resiliency.

[a] BLM = Bureau of Land Management [b] CNP = Canyonlands National Park [c] DNM = Dinosaur National Monument [d] GCNRA = Glen Canyon National Recreation Area
[e] GCNP = Grand Canyon National Park [f] GCD = Glen Canyon Dam

4.5 Status of Populations

This section describes the demographic status of each of the six Humpback Chub populations. Although these populations have existed for millennia, most were described in only the last 35–50 years:;Black Rocks in 1976 (Kidd 1977); Westwater Canyon in 1979 (Valdez and Clemmer 1982); Desolation/Gray canyons in 1967 (Holden 1973); Cataract Canyon in 1980 (Valdez et al. 1982); and Yampa Canyon in 1968 (Holden 1973). Humpback Chub were photographed in the Grand Canyon in 1911 (Kolb and Kolb 1914), and the species was described from a holotype specimen caught by an angler in 1933 (Miller 1946).

Upper basin populations were first sampled in the 1960s and 1970s, but indices of fish abundance began in 1986 with the Interagency Standardized Monitoring Program (ISMP). The ISMP initially used catch rates (CPUE), adding mark-recapture abundance estimates in 1998. In the Grand Canyon, Humpback Chub were first surveyed in the early 1960's as part of the Glen Canyon Dam pre-impoundment studies (see references in Valdez and Ryel [1995], Webb et al. [2002]). Post-impoundment studies were conducted during 1977-78 (Minckley 1980; Carothers and Minckley 1981; Minckley 1997), and during 1987–1990 (Minckley 1988, 1989, 1997). Mark-recapture estimates began in 1987 in the LCR (Douglas and Marsh 1996) and in 1991 in the mainstem (Valdez and Ryel 1995).

Obtaining mark-recapture estimates and CPUE indices is highly challenging because of the notorious difficulty in sampling Humpback Chub in their habitats. Reliable abundance estimates are not available for young and sub-adult Humpback Chub in the upper basin because of the difficulty of capturing fish and distinguishing them from sympatric Roundtail Chub and Bonytail. The age structure, survival, and recruitment of the Grand Canyon population have been quantified and provide additional information on population persistence.

Abundance estimates of Humpback Chub are available for the upper basin over the last 17 years (1998–2016; Table 10), though not annually for any single population, and for the last 23 years (1989–2012) in the Grand Canyon. This period of monitoring is but a snapshot in the historical pattern of population numbers, and the long-term dynamics of these populations are not well understood. If generation time for the species is 8 years (see section 5.1), quantitative monitoring has been conducted for less than three generations.

Persistence in this assessment is inferred through population models to compute the intrinsic rate of growth or lambda (λ) for each population. Each lambda value was derived as 1 minus the slope of the regression model fit to natural log-transformed adult abundance estimates. The 95% confidence interval for lambda was computed as the standard error of the slope times 1.96. Akaike information criterion scores adjusted for small samples sizes (AIC_c) were used to help determine the model of best fit (Table 11).

Table 10. Annual population estimates for adult Humpback Chub (age 4+, ≥ 200 mm TL) in the five upper basin populations. N = population estimate, Low CI = lower 95% confidence interval, High CI = upper 95% confidence interval, "--" = no estimate. The 2016 estimate for Westwater Canyon is preliminary and therefore italicized.

Year	Black Rocks[a]			Westwater Canyon[b]			Desolation/Gray canyons[c]			Cataract Canyon[d]			Yampa Canyon[e]		
	N	Low CI	High CI	N	Low CI	High CI	N	Low CI	High CI	N	Low CI	High CI	N	Low CI	High CI
1998	880	572	1,431	6,747	4,001	11,636	--	--	--	--	--	--	--	--	--
1999	994	810	1,245	3,520	2,513	4,979	--	--	--	--	--	--	--	--	--
2000	740	490	1,150	2,266	1,742	2,975	--	--	--	--	--	--	317	184	623
2001	--	--	--	--	--	--	3,087	0	9,138	--	--	--	320	245	438
2002	--	--	--	--	--	--	16,931	0	34,455	--	--	--	277	157	512
2003	590	350	1,040	2,520	1,814	3,554	6,935	1,742	12,127	468	217	1,705	224	123	434
2004	560	360	950	2,724	2,034	3,689	--	--	--	273	144	589	--	--	--
2005	--	--	--	2,000	1596	2,530	--	--	--	295	155	652	--	--	--
2006	--	--	--	--	--	--	2,856	1,550	4,162	--	--	--	--	--	--
2007	283	179	478	1,212	972	1,532	1,794	788	2,801	--	--	--	--	--	--
2008	395	250	655	1,139	954	1,379	--	--	--	--	--	--	--	--	--
2009	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2010	--	--	--	--	--	--	2,520	445	4,594	--	--	--	--	--	--
2011	379	239	642	1,467	1,175	1,861	--	--	--	--	--	--	--	--	--
2012	404	298	571	1,315	1,022	1,713	--	--	--	--	--	--	--	--	--
2013	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2014	--	--	--	--	--	--	1,863	924	2,802	--	--	--	--	--	--
2015	--	--	--	--	--	--	1,672	756	2,589	--	--	--	--	--	--
2016				*2,002*	*1,118*	*2,886*									

[a] Francis and McAda (2011); revised by Francis et al. (2016)
[b] Estimates for 1998-2016 from Hines et al. (2016)
[c] Jackson and Hudson (2005); Badame (2010, 2011); revised by Howard and Caldwell (2017); estimates for 2001–2003 unreliable, of low precision, not recommend for analysis
[d] Badame (2008)
[e] Haines and Modde (2002); Finney (2006)

Table 11. One- and two-phase models to determine lambda trajectories based on adult abundance estimates for three populations of Humpback Chub (provided by C. Yackulic, Grand Canyon Monitoring and Research Center, U.S. Geological Survey). The years and total number of abundance estimates (n) are provided in parentheses after each population name. Lowest AIC_c values (AIC_c is used when few point estimates contribute to the model) determine best model, also indicated in bold.

Population	**AIC_c**	**β_0**	**B_1**	**B_2**	**λ_1 (95% CI)**	**λ_2 (95% CI)**
Black Rocks (1998-2012, n=9)						
One-phase (linear) model	**6.9**	**6.3**	**-0.07**		**0.93 (0.90–0.96)**	
Two-Phase (separate lambda trajectories) model	10.5	6.1	-0.12	-0.03	0.88 (0.81–0.94)	0.97 (0.91–1.03)
Westwater Canyon (1998-2016, n=11)						
One-phase (linear) model	**17.8**	**7.7**	**-0.06**		**0.94 (0.89–0.98)**	
Two-Phase (separate lambda trajectories) model	18.5	7.5	-0.16	-0.01	0.84 (0.75–0.94)	0.99 (0.93–1.05)
Grand Canyon (1989-2008, n=20)						
One-phase (linear) model	-3.7	8.77	-0.03		0.97 (0.96–0.99)	
Two-Phase (separate lambda trajectories) model	**-67.5**	**8.47**	**-0.07**	**0.07**	**0.93 (0.93–0.94)**	**1.07 (1.06–1.08)**

4.5.1 Black Rocks—The Black Rocks population occupies the smallest geographic area (1.4 km) of the six Humpback Chub populations. The estimated number of adults (≥ 200 mm TL) has ranged from 994 in 1999 to 283 in 2007 (Figure 27A; Table 10). The latest estimate is 404 adults in 2012, and the average of the nine estimates is 581 adults. These estimates declined from the beginning of the census in 1998, but leveled off from 2007 to 2012, with the last three estimates approximately equal at ~400 adults. The adult CPUE indices are also similar from 2003 to 2012, following lower indices from 1988 to 1997 and highest indices in 1998 and 1999 that correspond with the highest adult abundance estimates (Figure 27B).

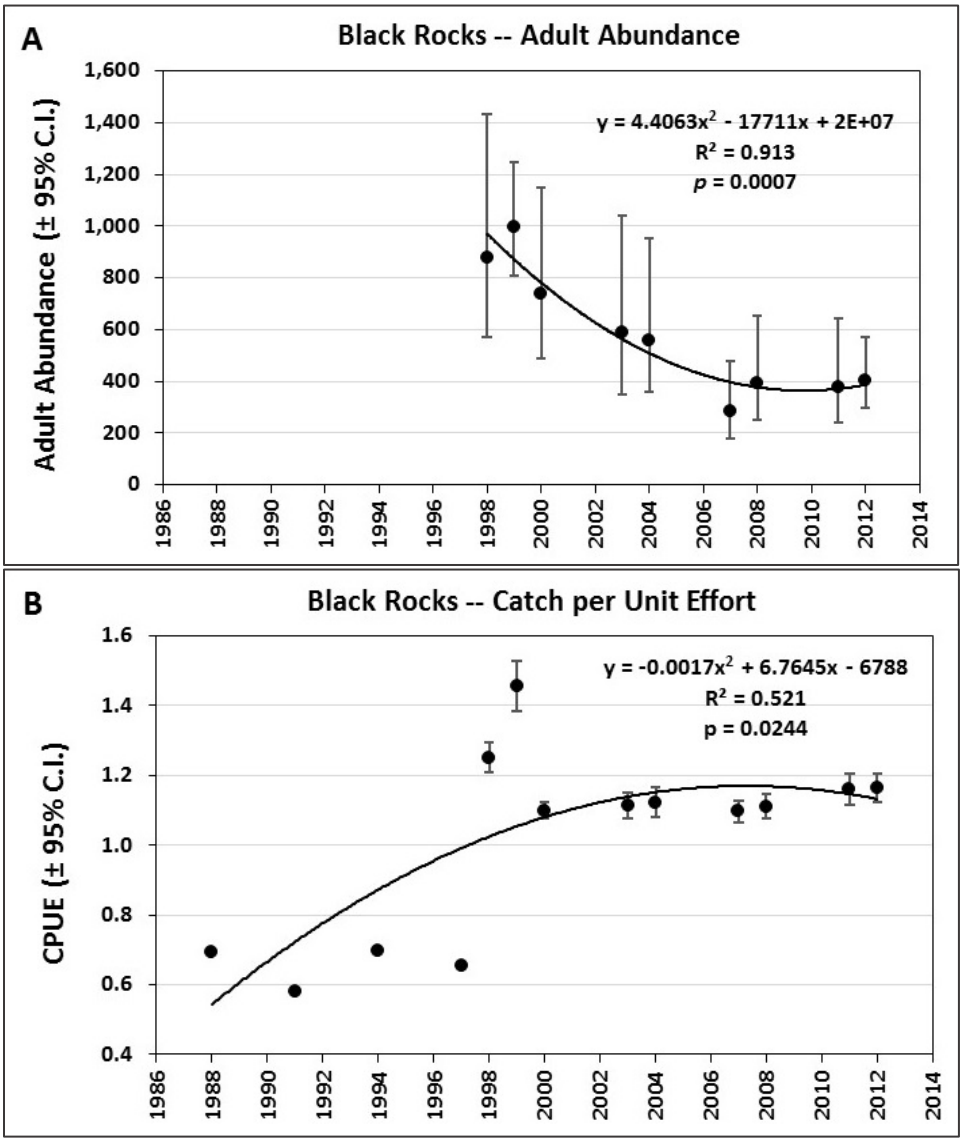


Figure 27. Line of best fit for (A) annual abundance (1998–2012) and (B) trammel net CPUE (1988–2012) of adult Humpback Chub in the Black Rocks population. Adult abundance estimates from Francis et al. (2016). CPUE data provided by Travis Francis (U.S. Fish and Wildlife Service, Personal Communication, August 2016).

Population Trajectory and Lambda—A retrospective analysis of the nine abundance estimates over a period of 15 years (1998–2012) shows that the number of adults in Black Rocks has declined since mark-recapture abundance estimates were initiated in 1998, as indicated by a single intrinsic growth rate (λ) of 0.93 (95% C.I. = 0.90-0.96; Figure 28). Since 2007 declines have potentially been arrested and population estimates are stabilizing

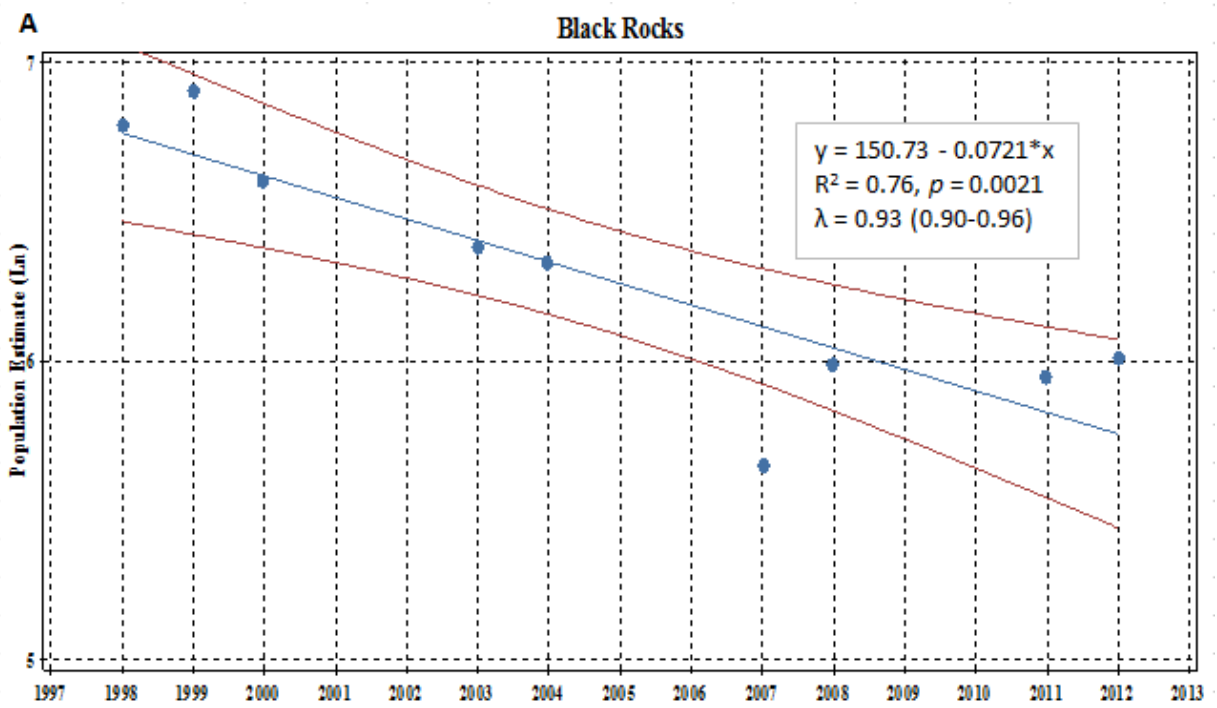


Figure 28. One-phase lambda (λ) for adult Humpback Chub in the Black Rocks population. 95% confidence bounds are shown as bands and computed intervals are presented parenthetically for lambda values.

Survival and Movement—Estimated mean survival rate of adult Humpback Chub remained within a narrow range at 0.64–0.70 for 1998–2011, but differed by size and age; e.g., 0.86 for fish 200 mm TL and 0.69 for fish 400 mm TL (Francis et al. 2016). The decline in adult numbers prior to 2007 is attributed to low adult survival that led to the loss of the larger and presumably more fecund individuals. This also led to reduced reproduction and survival of young, such that recruitment was not keeping up with adult mortality; all brought about by drought and low river flow (see section 5.2.2).

Annual adult abundance has remained relatively stable since 2007, suggesting that recruitment is currently offsetting annual adult mortality, but not to a level that is increasing adult abundance (Francis et al. 2016). Key demographic factors affecting this population are survival and recruitment by young, and survival of the oldest and largest adults to maintain high reproductive potential. A large cohort reported for 2010 is expected to reflect as increased adult numbers for the next scheduled estimates of 2016–2017 (Francis et al. 2016).

Movement of adults between Black Rocks and Westwater Canyon (16 km apart) may be affecting recruitment in the former population, but not the latter. The annual transition of 1.4% of adults from Black Rocks to Westwater Canyon doesn't reflect a measureable change for either population because of the small number of fish. However, the 1.8% annual transition of fish from the larger Westwater Canyon population to the smaller Black Rocks population is measureable (Francis et al. 2016).

Using the 2012 estimates of 404 adults in Black Rocks and 1,315 adults in Westwater Canyon, about six adults could transition annually from Black Rocks to Westwater Canyon for a net increase in adult abundance of 0.5%; but ~24 adults would transition from Westwater Canyon to Black Rocks for a net increase of 5.9%. For Black Rocks, at an annual mortality of 0.30, 121 adults are lost annually to mortality and 6 to transition, but 24 are gained in transition from Westwater Canyon for a net loss of only 103 adults annually. This offsets mortality to 18 adults (121 - 103 = 18) that represents ~22,500 eggs (9 x 2,500 eggs), which could be a significant number of young for the smaller Black Rocks population.

The Black Rocks population has declined since population estimates started in 1998 by ~7% annually. However, the four recent estimates from 2007 to 2012 shows that the number of adults could be stable, but the recent trend is uncertain. The less rigorous, catch-based monitoring dating back to 1988 indicates the population may have been stable over the past 30 years.

5.5.2 Westwater Canyon—The Westwater Canyon population occupies the second smallest geographic area (19.3 km) of the six populations of Humpback Chub. Estimates of adult abundance have ranged from 10,148[10] in 1995 to 1,139 in 2008 (Figure 29A; Table 10). Estimates of adult abundance declined from 1995 to 2000, but appear to have leveled off for the past 16 years. These estimates follow the same pattern as the adult CPUE indices, but also indicate a higher prior population level starting in 1988 (Figure 29B). The latest Recovery Program approved estimate is 1,315 adults in 2012, and the average of 13 estimates is 3,528 adults. A preliminary abundance estimate for Humpback Chub in Westwater Canyon in 2016 is 2,002 adults (Hines 2016), which provides some evidence of a potential population stabilization since 2000. Utah Division of Wildlife conducted another estimate in 2017 for which results will be available in 2018.

[10] The first real commitment to mark / recapture population estimation began in 1998.

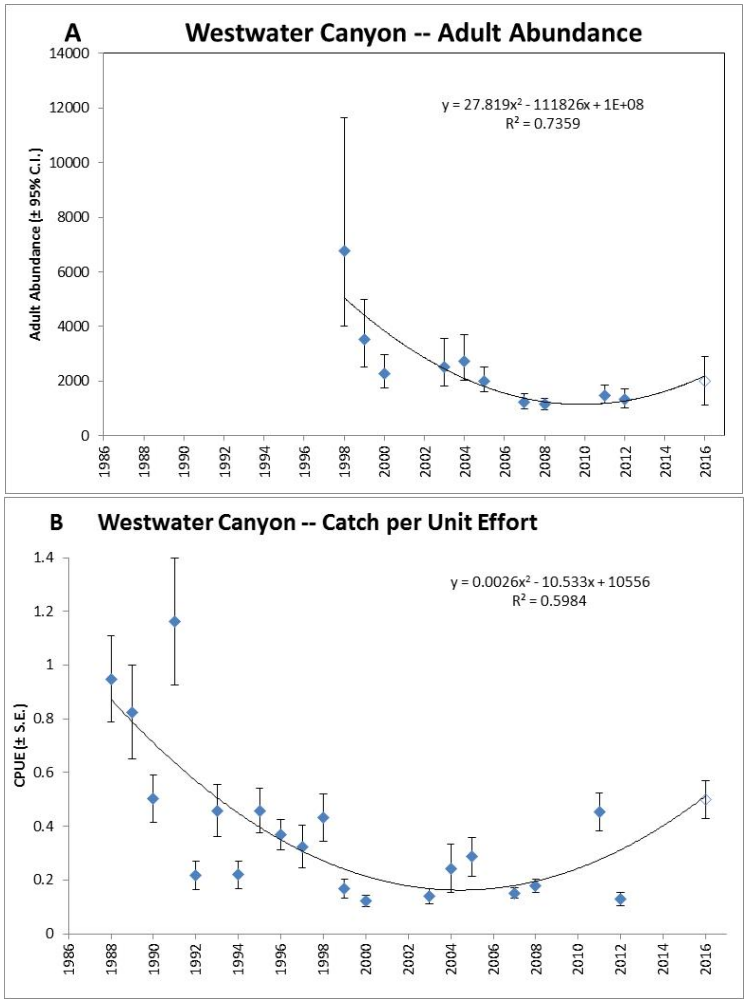


Figure 29. Line of best fit for (A) annual abundance (1994–2012) and (B) trammel net CPUE (1988–2012) of adult Humpback Chub in the Westwater Canyon population. Adult abundance estimates for 1998–2012 from Hines et al. (2016; data for 2016 preliminary). The CPUE data were provided by Brian Hines (UDWR, Pers. Comm. August, 2016).

Population Trajectory and Lambda—A retrospective analysis of the 11 abundance estimates over a period of 18 years (1998–2016) shows that the number of adult Humpback Chub in Westwater Canyon has been in apparent decline, as indicated by a single intrinsic growth rate (λ) of 0.94 (0.89-0.98; Table 11; Figure 30). Since 2007 the declines have potentially been arrested and population estimates are stabilizing,

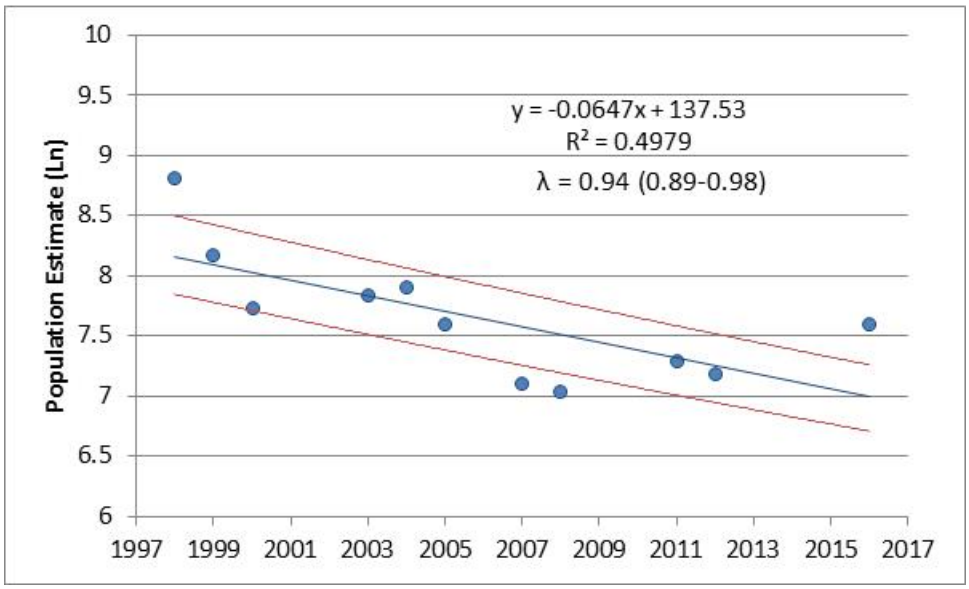


Figure 30. One-phase lambda (λ) for adult Humpback Chub in the Westwater Canyon population. 95% confidence bounds are shown as bands and computed intervals are presented parenthetically for lambda values.

Survival and Movement—Estimated mean survival rate of adult Humpback Chub in Westwater Canyon for 1998-2011 remained in a narrow range of 0.69–0.75, with a mean of 0.70, but differed by size and age; e.g., 0.85 for fish at 200 mm TL and 0.58 for fish at 400 mm TL (Hines et al. 2016). As with the Black Rocks population, the decline in adult numbers is attributed to low adult survival and reduced recruitment, where recruitment was not keeping up with adult mortality caused by natural attrition and low river flow from drought. As with the Black Rocks population, this information indicates that reproduction and survival of young need to be sufficient for recruitment to exceed annual adult mortality, and all these vital rates could be suppressed during periods of drought (see section 5.2.2).

Small numbers of fish move freely between Westwater Canyon and Black Rocks (16 km upstream), such that some have considered these populations as a single core population for the upper basin (e.g., Kaeding et al. 1990; USFWS 2002). The number of fish that leave Westwater Canyon is probably insignificant to adult numbers, as transition rates in and out of Westwater Canyon are relatively low at 1.4% and 1.8%, respectively; this is a net loss of only ~18 adults annually from a population of ~1,315 adults. However, as described for the Black Rocks population, transition of adults from Westwater Canyon to Black Rocks could involve sufficient numbers of individuals to affect adult recruitment when the smaller Black Rocks population is at a low level.

The Westwater and Black Rocks populations are in close proximity and subject to contaminant spills, although recorded spills are rare. On July 24, 1989, a large ash-laden flood entered Westwater Canyon and killed or displaced a large, but unquantified, number of

fish (Miles Moretti, Utah Division of Wildlife Resources, Personal Communication, July 1989). The decline in the adult CPUE for 1989 to 1990 may be attributed to this event, but CPUE increased dramatically afterward to its highest level in 1991, indicating that the population recovered from this event and showed high resiliency to catastrophic events.

As with the Black Rocks population, the Westwater Canyon population of Humpback Chub experienced a decline in adult numbers from 1994 to 2007, followed by a period of relative stability with a small increase. Analysis of lengths suggests that the population for 2011–2012 consisted of older fish with few young recruits (Hines et al. 2016). The low number of younger fish could be a result of poor reproduction and survival during recent drought that provided favorable conditions for invasive nonnative fishes and Roundtail Chub. These species likely have a combined carrying capacity and the decline of Humpback Chub may be linked to a high abundance of Roundtail Chub (Hines et al. 2016).

The Westwater Canyon population declined dramatically since reliable population estimates began in 1998, by ~10% annually. However, the four recent estimates from 2007-2016 indicate that the numbers of adults could be stable, but recent trends are uncertain. The less rigorous, catch-based monitoring data set (initiated in 1988) indicates that the population may be experiencing a period of stability, albeit at low densities, which began in 1992 and has continued through the present.

4.5.5.3 Desolation/Gray canyons—The Desolation/Gray canyons population occupies the largest geographic area (113 km) of the five upper basin Humpback Chub populations. Estimates of adult abundance have ranged from 2,856 in 2006 to 1,672 in 2015 (Figure 31A; Table 10, estimates for 2001-2003 are imprecise and were not used in this analysis [Badame 2012]). The average of the five estimates is 2,141 adults. These estimates are too few to make any interpretation of population trajectory, as the data fit is poor to the model of best fit ($R^2 = 0.4129$), and the data do not show a significant slope ($p = 0.5871$). The adult CPUE indices for 1985 to 2015 indicate that adult numbers have been variable, with a possible early decline and more stable numbers from 2006 to 2015 (Figure 31B).

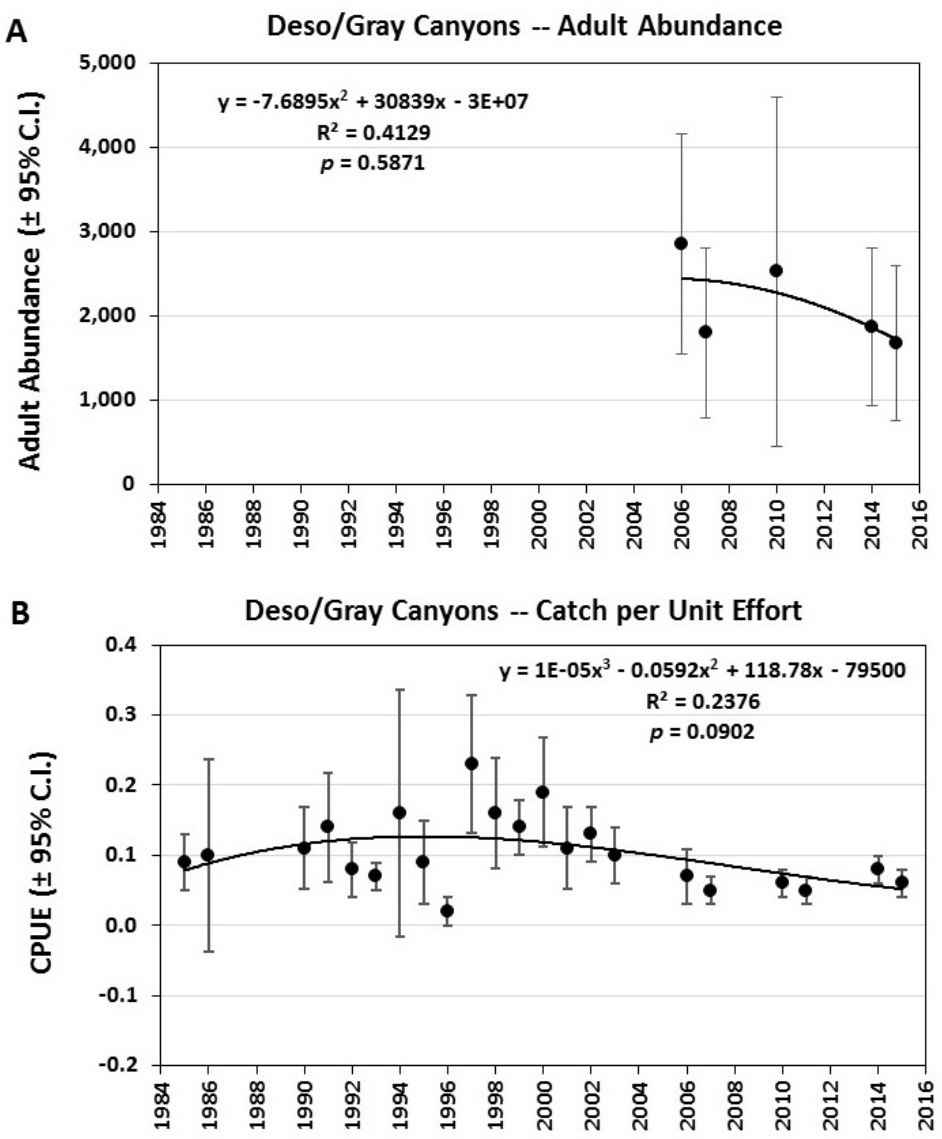


Figure 31. Line of best fit for (A) annual abundance (2006–2015) and (B) trammel net CPUE (1985–2015), of adult Humpback Chub in the Desolation/Gray canyons population. Adult abundance estimates from Howard and Caldwell (2017). The CPUE data were provided by Brian Hines (Utah Division of Wildlife Resources, Personal Communication, August, 2016).

Population Trajectory and Lambda—A retrospective analysis of five abundance estimates over a period of 10 years (2006–2015) shows no apparent reliable pattern for the number of adult Humpback Chub in Desolation/Gray canyons (Figure 32). A one-phase lambda indicates a decline of ~4% per year ($\lambda = 0.96$ [0.91-1.01]), but the number of estimates is too small and variable to reach any reliable conclusion for population trajectory.

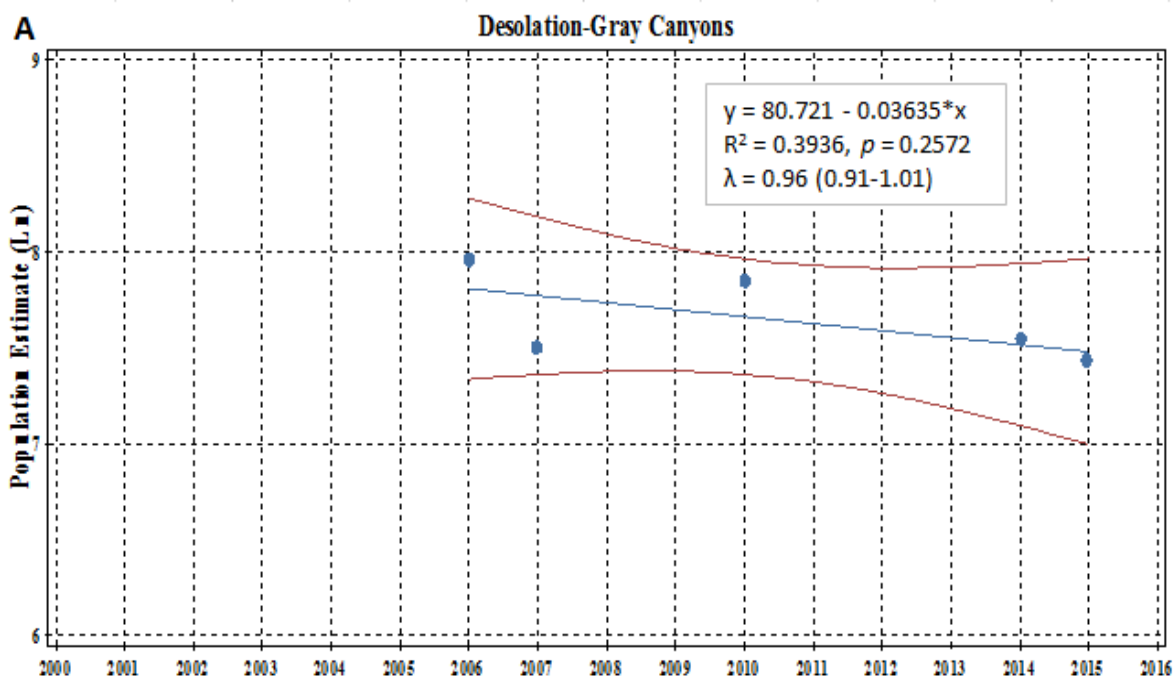


Figure 32. One-phase lambda (λ) for adult Humpback Chub in the Desolation/Gray canyons population. 95% confidence bounds are shown as bands and computed intervals are presented parenthetically for lambda values.

Survival and Movement—Estimated mean survival of adult Humpback Chub in Desolation/Gray canyons for 2001–2015 ranged from 0.53–0.69, which is lower than adult survival in Black Rocks (0.64–0.70; Francis et al. 2016) and Westwater Canyon (0.69–0.75; Hines et al. 2016). Lower survival in Desolation/Gray canyons may be due to the large numbers of Channel Catfish and recent invasions of Smallmouth Bass and Walleye that are either absent or present in low numbers in other populations (Howard and Caldwell 2017). These predators may be sufficiently large to consume sub-adult and small-bodied adult Humpback Chub of this population.

Nonnative fish predation is a particular problem in the Desolation/Gray canyons population. Smallmouth Bass, first captured in this area in 2001 (Jackson and Hudson 2005), have increased in number and in 2004 large-scale removal was implemented in the Green and Yampa rivers, including Desolation/Gray canyons. Although Smallmouth Bass densities have declined by as much as 50%, their distribution has expanded and a decline of Humpback Chub in the upper 72 km of Desolation Canyon correlates strongly with the appearance and persistence of this predator (Badame et al. 2013).

Recruitment in the Desolation/Gray canyons population is not known, as with the other populations in the upper basin. The proportions of first-year adults to older adults in the population has been suggested by Howard and Caldwell (2017) as one index of recruitment,

but fish cannot be confidently classified as Humpback Chub from morphological examination.

Little exchange of individual Humpback Chub occurs between Desolation/Gray canyons and the other populations to enhance recruitment. This population is ~257 km downstream from Yampa Canyon and ~217 km upstream from Cataract Canyon, and very little movement of individuals from other populations has been documented (see section 4.1.6).

The Desolation/Gray canyons population has been subject to several catastrophic events. Large floods laden with debris and ash have entered Desolation Canyon following range fires. Also, a ruptured well released oil into the Green River upstream of this area in 2014. These events took place when river volume was low and there was little dilution of the debris and ash that suffocated fish, although the number of dead fish was not documented. The population appears to have recovered from these events, and as with other populations, the species shows high resiliency to these catastrophic events.

The demographic evidence is insufficient to reach any reliable conclusion about the past or present trajectory of the Desolation/Gray canyons population of Humpback Chub. Estimates of abundance indicate that the number of adults is between ~1,500 and 3,000, and that numbers may be in a recent decline. Additional estimates, scheduled for 2018 and 2019, are needed to provide a better understanding of the trajectory of this population. The less rigorous, catch-based monitoring starting in 1985 serves as the basis for our contention that this population has demonstrated stability over the past 30+ years.

4.5.5.4 Cataract Canyon—The Cataract Canyon population is the second smallest population of Humpback Chub (the DNM population is smaller). Only three estimates of adult abundance are available for the Cataract Canyon population; 468 in 2003, 273 in 2004, and 295 in 2005 (Figure 33A; Table 10). The average of the three estimates is 345 adults. Abundance estimates are too few to show a pattern.

Fourteen adult CPUE indices are available from Cataract Canyon for trammel nets catches over a period of 25 years (1991–2015; Figure 33B). These indices show a variable, but persistent population with no significant increase or decrease for the period of sampling (p = 0.5984). The more recent catch rates, since 2003, indicate a higher number of adults than prior estimates, but the data are too variable and are a poor fit to the model of best fit (R^2 = 0.0891).

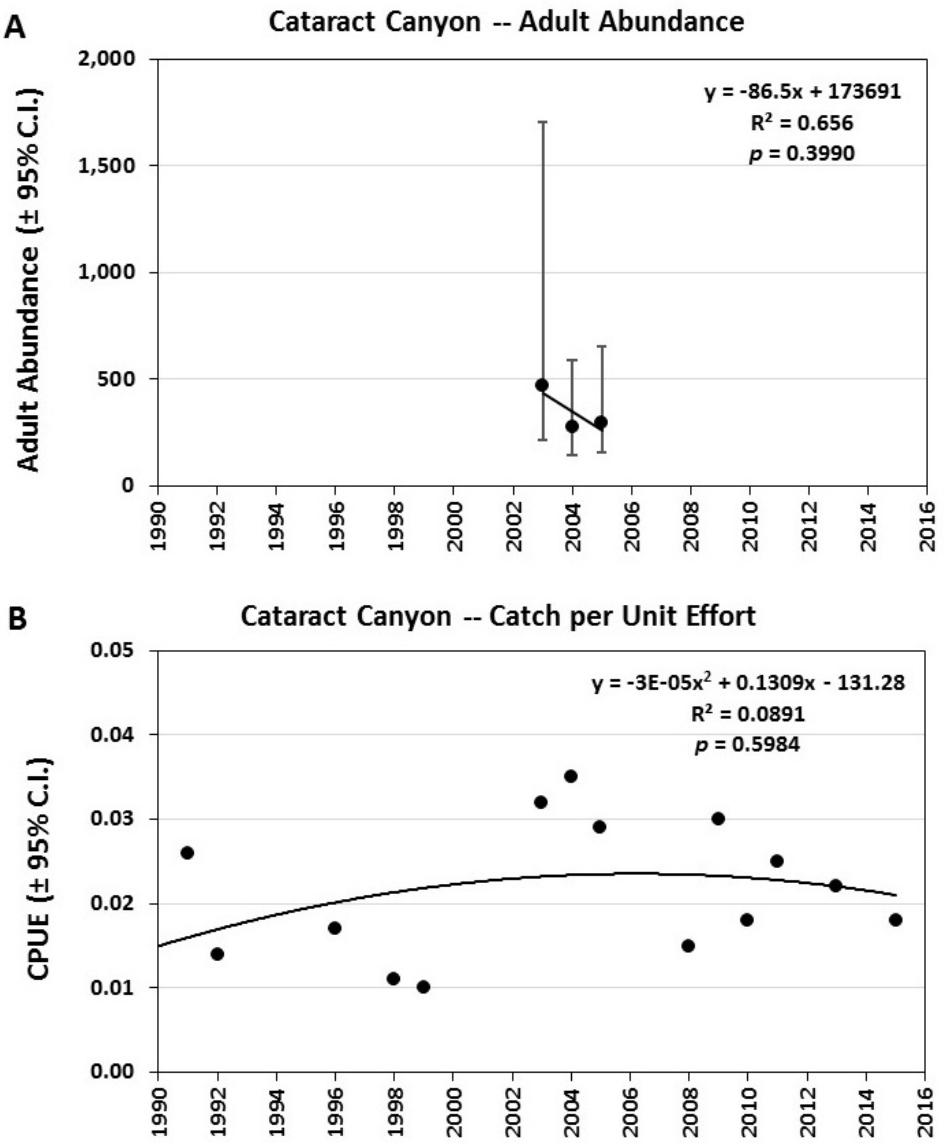


Figure 33.Line of best fit for (A) annual abundance (2003–2005) and (B) trammel net CPUE (1991–2014) of adult Humpback Chub in the Cataract Canyon population. Adult abundance estimates and CPUE data from Badame (2008) and Ahrens (2015).

Population Demography—This population is a remnant of the Humpback Chub population that probably extended the full length of Cataract Canyon for a distance of ~56 km from the confluence of the Green and Colorado rivers downstream to Sheep Canyon. The lower 19 km of Cataract Canyon was inundated by Lake Powell in the early 1980s, but recent receding reservoir levels are exposing historical habitat that could allow for a downstream expansion of this population—as has been seen in western Grand Canyon with receding levels of Lake Mead.

The number of fish captured in Cataract Canyon has remained low for the last 25 years, but the area is difficult to sample and only gears used to catch large fish (trammel nets) are generally used (Table 12; Valdez et al. 1982; Valdez 1990; Badame 2008). Efforts to capture younger life stages with seines, minnow traps, and fyke nets have yielded a few fish, but the size and age composition of the population is unknown.

Table 12. Numbers of Humpback Chub by life stage captured in Cataract Canyon. "--" indicates that gear types were not used to sample a particular life stage of fish.

Year[a]	Larvae	Young-of-Year	Juvenile	Adult	Total
1980	--	--	--	1	1
1985	0	7	1	2	10
1986	8	4	2	3	17
1987	0	4	11	6	21
1988	2	4	42	11	59
1991	--	--	--	36	36
1992	--	--	--	19	19
1996	--	--	--	23	23
1998	--	--	--	15	15
1999	--	--	--	14	14
2003	--	--	--	44	44
2004	--	--	--	43	43
2005	--	--	--	31	31
Total	10	19	56	248	333

[a]1980 from Valdez et al. (1982); 1985-1988 from Valdez (1990); 1991-2005 from Badame (2008)

Observers in the field have noted that Humpback Chub in Cataract Canyon are smaller in body size than fish from other populations (e.g., Valdez 1990, Badame 2008). Meretsky et al. (2000) quantified this observation by comparing length-weight relationships for adults in primary populations during the early to mid-1990's, and showed that adults in Cataract Canyon were smallest and had the lowest condition of any population. Badame (2008) found length weight relationships for 2003-2005 that were nearly identical to those reported by Meretsky et al. (2000), and suggested that small size and low condition may be inherent traits of the Cataract Canyon population and reflective of the extreme hydraulic condition found in the deep, swift waters of the canyon.

An absence of adults over 300 mm TL in Cataract Canyon suggests a lower reproductive potential and may help to explain the small population size. Apparent annual growth rates of individual Humpback Chub in Cataract Canyon are also slower than those reported for all other upper basin populations (Valdez 1995; Meretsky et al. 2000; Jackson and Hudson 2005). This lack of later life stage growth creates a narrow unimodal size distribution for fish over 200 mm TL. Badame (2008) found that this phenomenon intensified over the 2003–2005 period, when all presumed adults captured fell within a size range of ~60 mm.

The Cataract Canyon population is located immediately downstream of the confluence of the Upper Colorado and Green rivers, and thus, occupies an area with the highest contemporary spring peak flow of the six populations. Spring flow is commonly over 50,000 cfs and approached 100,000 cfs each in 1983 and 1984. This hydrologic regime provides a constantly turbulent habitat laden with debris and sediment that may suppress fish size and growth, but provides a reliable food source and greater security and protection than other populations subject to lower flow.

The Cataract Canyon population has not been subject to any known catastrophic events, and is a long distance downstream from other populations; e.g., ~190 km downstream from the Westwater Canyon population of the upper Colorado River and ~217 km downstream from the Desolation/Gray canyons population of the Green River. With no perennial tributaries in Cataract Canyon and a great distance to other populations, there is a low probability for exchange of individuals with other populations. Historical connection with the Grand Canyon population may be possible, but the Cataract Canyon population currently remains largely isolated (Badame 2008), except for an occasional fish moving upstream to the Green River and Desolation/Gray canyons (see section 4.1.6). Demographic data are insufficient to conduct a retrospective lambda analysis of the Cataract Canyon population.

Humpback Chub have been consistently caught in Cataract Canyon during periodic sampling since 1980, albeit in small numbers, and young life stages are found when the appropriate sampling gear is deployed. Based on this information, it appears that the population is small but persisting; the trajectory of adult numbers is unclear.

4.5.5.5 Dinosaur National Monument—The DNM population is the smallest of the six populations, with any fish remaining being below detection limits. Estimates range from 320 adults in 2001 to 224 adults in 2003 (Figure 34; Table 10), but the low number of individuals in recent years has precluded additional estimates. Only three Humpback Chub were caught in Whirlpool Canyon in 2003 and two and eight in Yampa Canyon in 2003 and 2004, respectively (Finney 2006). The last humpback chub was captured in Whirlpool Canyon in 2006 (Bestgen & Irving 2006). The number of Humpback Chub in Yampa Canyon is small with no fish captured recently (Jones 2012, 2013, 2014).

The historical distribution and abundance of the Humpback Chub population in DNM is not well known, and it is unclear if substantial numbers of fish were ever present in this area. In the 1940s, Humpback Chub were found in the lower Yampa River and in Whirlpool Canyon (Tyus 1998). Holden (1973) reported catching 26 “humped chubs” near Echo Park in 1969. By 1987–1989, only two Humpback Chub were caught in upper Whirlpool Canyon, none in Lodore Canyon, and 131 in Yampa Canyon (Karp and Tyus 1990). For the purpose of this assessment, it is assumed that a population once extended from the lower Yampa River into the Green River and downstream through Echo Park, and Whirlpool Canyon, based on the

persistence of apparent suitable habitat and a few available historic records of collected specimens, as previously described.

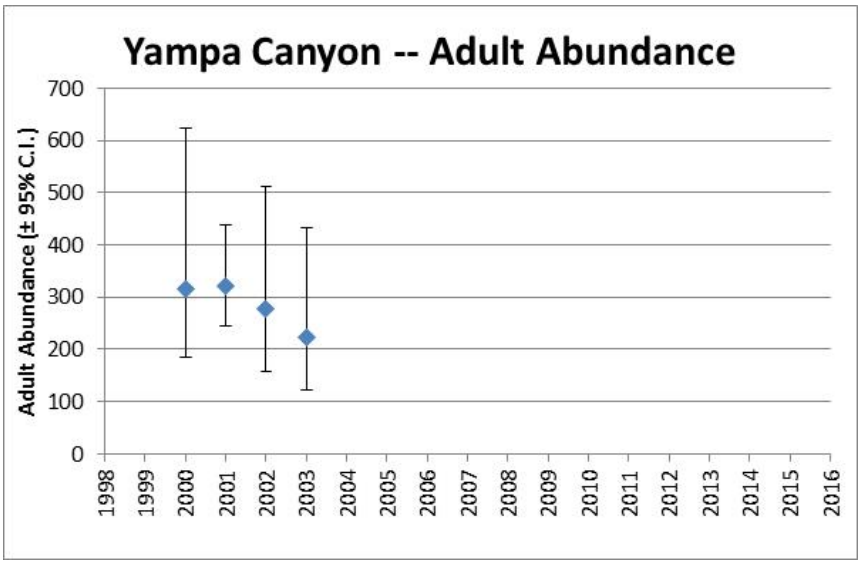


Figure 34. Line of best fit for annual abundance (2000–2003) of adult Humpback Chub in the Yampa Canyon population. Estimates from Haines and Modde (2002) and Finney (2006).

The Humpback Chub is now rare in Whirlpool Canyon, with a few fish remaining in the lower Yampa River. It appears that the fish in the Green River were negatively affected by the cold releases from Flaming Gorge Dam starting in 1963, and the fish in the Yampa River were negatively affected by low river flows and a simultaneous expansion of Smallmouth Bass starting in ~2000. Despite this apparent decline in the number of Humpback Chub in DNM, the geomorphic framework and general habitat do not appear to have changed appreciably, other than the effect of nonnative fish and low flow from drought. A temperature control device on Flaming Gorge Dam has warmed the Green River, and an ongoing nonnative fish control program is reducing the abundance of Smallmouth Bass. The habitat is otherwise suitable, but immigration from other populations is too low for the population to rebuild naturally. Intervention (e.g., translocation or stocking) will be necessary to restore numbers of fish to the area to restart the population.

A genetic analysis of Humpback Chub from Yampa Canyon was inconclusive as to the distinctness of the fish (Douglas and Douglas 2007), suggesting that introgressive hybridization had been occurring in that population for some time, as reported by Tyus (1998). In 2007, ~400 juvenile *Gila* spp. were removed from Yampa Canyon and transferred to two hatchery facilities to establish a refuge population. The fish were grown to identifiable size and no fish with Humpback Chub morphology or genetics were found; all fish had the same genetic makeup as the Roundtail Chub of the same population (Bohn 2016). This collection of fish confirmed that the number of Humpback Chub remaining in Yampa Canyon is quite low. Recent sampling in Whirlpool Canyon of the adjacent Green River

showed that the number of Humpback Chub in this canyon is also low (Bestgen & Irving 2006).

It appears that the cause of decline for the DNM population is a combination of factors linked to effects in two river systems. Fish numbers in Whirlpool Canyon apparently declined because of cold water temperature in the Green River following construction of Flaming Gorge Dam in 1962 and the invasion of various nonnative fish predators and competitors. The decline of Humpback Chub in the Yampa River (a largely unregulated river) was apparently caused by unusually low natural flow and a corresponding expansion of predaceous Smallmouth Bass in 2000. The number of Roundtail Chub also expanded at this time, increasing competition and the likelihood of hybridization. The Yampa River near Maybell, CO, has an average flow of ~368 cfs (USGS 09251000, 1916-2015), but on August 31, 2002, the flow dropped to 1.8 cfs, which was the lowest recorded flow in 100 years. This period of low flow allowed for expansion of the already present Smallmouth Bass and Roundtail Chub (Haines et al. 2006).

The population of Humpback Chub in DNM may have historically functioned somewhat like the population in the Grand Canyon, where a large portion of fish reside in the mainstem Colorado River and move annually to spawn and rear in the smaller, seasonally-warmed LCR. The juxtaposition of Echo Park and Whirlpool Canyon on the Green River and the lower Yampa River may be an analogue to the situation in the Grand Canyon. The setting in the lower Yampa River and adjacent Green River may provide a framework for restoring this population, where the fish would reside primarily in the Green River and ascended the Yampa River for spawning and rearing.

Dinosaur National Monument is a long distance from the other Humpback Chub populations, and it is very unlikely that natural demographic rescue from large-scale immigration will occur. The mouth of the Yampa River is ~257 km upstream from the Desolation/Gray canyons population, and movement of significant numbers of fish from that population is not likely (see section 4.1.6). Restoring the DNM population will require specific management actions, such as translocation or stocking of fish into Whirlpool and Yampa canyons.

Successful translocations of Humpback Chub in the Grand Canyon have demonstrated the ability of the species to adjust to being displaced to new locales. This strategy of moving wild juveniles from one population to new or historical habitat may be possible for restoring the DNM population. Alternatively, a broodstock of upper basin fish has been recommended (Bohn and Wilson 2017) for hatchery production of fish to be stocked into historical habitat.

The Dinosaur National Monument population is currently below detection limits and is now considered functionally extirpated. Because immigration of Humpback Chub into this population is low, the probability of natural rescue effects is low and intervention in the form of translocations or hatchery stocking will be necessary to restore numbers to the area.

4.5.6 Grand Canyon—The Grand Canyon population is the largest and most extensively distributed population of Humpback Chub. It exists as a core population in the lower 18 km of the LCR, as well as ~406 km of the mainstem Colorado River from RM 30 to RM 282, as well as a translocated population in the lower 6 km of Havasu Creek. The estimated number of adults in the LCR core population has ranged from a high of 10,948 in 1989 to a low of 5,021 in 2001, and 7,650 in 2008 (Figure 35; Table 14; Coggins and Walters 2009). The average of 20 estimates for 1989–2008 is 7,080 adults.

More recent estimates for 2009–2012 indicate that the population has remained stable (Yackulic et al. 2014). The number of adults in the mainstem has apparently increased from ~250 in nine aggregations in 1995 (Valdez and Ryel 1995) to a much larger number, as indicated by the number of fish captured, especially in western Grand Canyon (Rogowski et al. 2017). The number of young has also increased in the mainstem with recent catches showing a cross-section of sizes and apparent ages that indicate successful mainstem reproduction (Kegerries et al. 2016; Rogowski et al. 2017).

Cause for the decline in adult numbers from 1989 to 2001 is unclear, but recruitment reconstructions suggest a peak in recruitment in the late 1970s to early 1980s of 13,500–18,500 age-2 fish annually, which led to the recorded peak in adult abundance in 1989 (Coggins 2008). After that peak, an overall decline was evident to the early 1990s, when annual recruitment stabilized at ~2,000 age-2 fish annually. This increase appears to be related to an increasing recruitment trend beginning perhaps as early as 1996, which corresponds to a new EIS and a change in dam operations to modified low fluctuating flows (Bureau of Reclamation 1996).

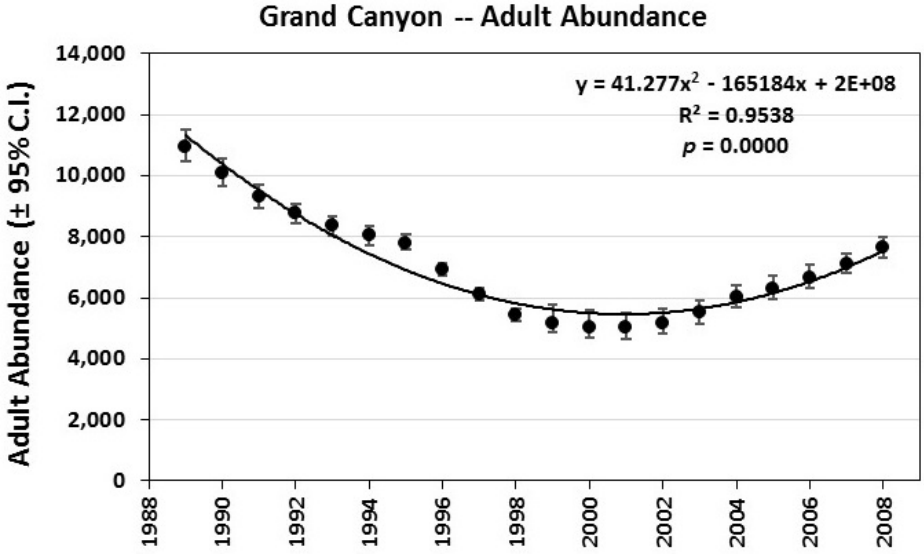


Figure 35. Estimated adult abundance of Humpback Chub (≥ 200 mm TL) for 1989–2008 in the LCR population from an Age Structured Mark-Recapture Model (ASMR; Coggins and Walters 2009).

Table 13. Estimated annual abundance of adult Humpback Chub (age 4+, ≥ 200 mm TL) for 1989–2008 in the LCR population from an Age Structured Mark-Recapture Model (ASMR; Coggins and Walters 2009). N = population estimate, Low CI = lower 95% confidence interval, High CI = upper 95% confidence interval.

Year	N	Low CI	High CI
1989	10,946	10,494	11,519
1990	10,111	9,660	10,544
1991	9,342	8,941	9,699
1992	8,766	8,424	9,070
1993	8,368	8,058	8,683
1994	8,045	7,739	8,332
1995	7,808	7,571	8,064
1996	6,945	6,711	7,150
1997	6,118	5,907	6,342
1998	5,432	5,227	5,622
1999	5,164	4,856	5,795
2000	5,048	4,680	5,616
2001	5,021	4,656	5,516
2002	5,185	4,820	5,633
2003	5,530	5,165	5,925
2004	6,020	5,685	6,423
2005	6,301	5,957	6,713
2006	6,673	6,318	7,095
2007	7,123	6,820	7,445
2008	7,650	7,335	8,009

Population Trajectory and Lambda—A retrospective analysis of 20 abundance estimates over 20 years (1989–2008) shows that the number of adult Humpback Chub in the LCR core population of Grand Canyon underwent a decline to the year 2001, and a subsequent increase to 2008 (Figure 36). The ASMR Age-Structured Mark-Recapture model results (used from 1989-2008) are likely negatively biased because it does not account for temporary emigration (skip-spawning), potentially underestimating abundances up to 20-30% in population estimates (Yackulic, personal communication, November 2017). More recent estimates, using a multi-state model that accounts for temporary emigration, show adult numbers at 11,500–12,000 (Appendix S3 of Yackulic et al. 2014), indicating that the population has remained relatively stable since 2008.

The pattern in adult numbers shows a clear change in trajectory after 2001, and a two-phase lambda of 0.93 (0.92-0.94) indicates that numbers declined at a rate of 7% per year in the first 13 years, followed by a lambda of 1.06 indicating that numbers increased at a rate of 6% per year in the subsequent 7 years (Figure 36B). The two-phased lambda is supported by the AIC_c calculated in Table 11. This analysis shows that despite a substantial decline in adult numbers over a period of what could have been a generation time (16 years, see section 5.1),

the number of adults has probably recovered—or surpassed the level of nearly 11,000 seen in the initial census of 1989 with the 2012 estimate of 12,000.

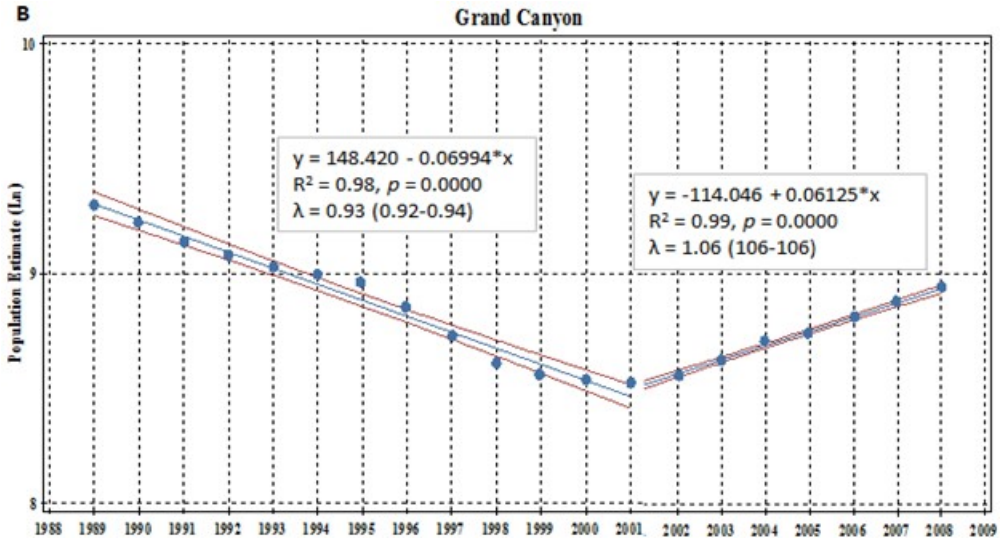


Figure 36. Two-phase lambda (λ) for adult Humpback Chub in the Grand Canyon population. 95% confidence bounds are shown as bands and computed intervals are presented parenthetically for lambda values.

Survival and Movement—The earliest estimated annual survival of mainstem Grand Canyon adults, based on mark-recapture data and open population models, was 0.755 (95% C.I. = 0.627–0.896; Valdez and Ryel 1995). Coggins and Walters (2009) determined that a natural mortality rate of 0.13 (survival rate = 0.87) provided the best solution for an individual-based simulation model (IBM) for adult Humpback Chub associated with the LCR. A more recent analysis shows survival of fish in the two systems is complicated by temperature. Humpback Chub that rear in the cold mainstem live ~5 times longer than fish in the seasonally-warmed LCR, but may take more than twice as long to reach adulthood and are ~40% less likely to survive to adults (Yackulic et al. 2014).

The survival estimates of 0.76–0.87 are considerably higher than survival for populations in Desolation/Gray canyons (0.53–0.69; Howard and Caldwell 2017), Black Rocks (0.64–0.70; Francis et al. 2016), and Westwater Canyon (0.69–0.75; Hines et al. 2016). The reason for different adult survival among populations is not clear, but is likely related to a number of factors, including habitat condition, food supply, river flow, predation, and competition. This may also be linked to the fact that Grand Canyon fish spawn in the less stressful environment of the LCR and return to the cold mainstem that aids recovery from spawning.

The demography of the Humpback Chub in the Grand Canyon is better understood than for the upper basin populations. This is largely because the core population is centered in the

LCR, where a large portion of the population can be sampled annually during spring spawning. Annual sampling has produced a robust data set that has been used to generate reliable estimates of survival, recruitment, and abundance (e.g., Coggins et al. 2006; Coggins and Walters 2009; Van Haverbeke et al. 2013; Yackulic et al. 2014).

Distribution—Initial surveys of Humpback Chub in the Grand Canyon characterized their distribution in the mainstem as nine aggregations, or small groups of fish with little evidence of reproduction. In 1995, the estimated number of adults in these aggregations ranged from 5 at Pumpkin Springs to 98 in Middle Granite Gorge (Valdez and Ryel 1995). Subsequent surveys by Persons et al. (2015) consolidated these aggregations into six (Table 14).

Table 14. Locations of six mainstem Humpback Chub aggregations in Grand Canyon, including river mile boundaries, estimated number of adults (N), and 95% confidence intervals (C.I.) estimated by Valdez and Ryel (1995). Redefined aggregation boundaries are described by Persons et al. (2015).

Aggregation	Aggregation Boundaries (RM)	Redefined Boundaries (RM)	N	95% C.I.
30-Mile	29.8–31.3	29.8–36.3	52	24–136
LCR inflow	57.0–65.4	57.0–77.2	3,482	2,682–4,281
Shinumo Creek inflow	108.1–108.6	107.8–110	57	31–149
Middle Granite Gorge	126.1–129.0	125.0–129.7	98	74–153
Havasu Creek inflow	155.8–156.7	155.8–159.2	13	5–70
Pumpkin Spring	212.5–213.2	212.5–216.0	5	4–16

An increasing number of Humpback Chub of all ages has been found in the mainstem in the last decade, possibly because of warmer dam releases starting in 2004 and expanding habitat in western Grand Canyon with the receding level of Lake Mead. In 2006, 739 age-0 Humpback Chub (13–66 mm TL) were captured in backwaters between Lees Ferry (RM 0) and Diamond Creek (RM 226) (Ackerman 2008). Many were captured at locations that correspond to known aggregations, but captures have become increasingly frequent throughout the mainstem, blurring the boundaries of the aggregations, and serving as evidence of mainstem reproduction. In 2014 and 2015, larvae and juveniles were found in western Grand Canyon (Kegerries et al. 2016), and a system-wide survey by AGFD in 2016 found 319 Humpback Chub (58–433 mm TL) between Lees Ferry (RM 0) and Pearce Ferry (RM 281) (Figure 37; Rogowski et al. 2017). These findings expanded the distribution of the species by ~108 km downstream (from Pumpkin Spring at RM 213 to Pearce Ferry at RM 282); the expansion is attributed to the lower elevation of Lake Mead exposing historical habitat starting in ~2002 beginning at RM 235 (Bridge Canyon), and possibly warmer dam releases starting in 2004.

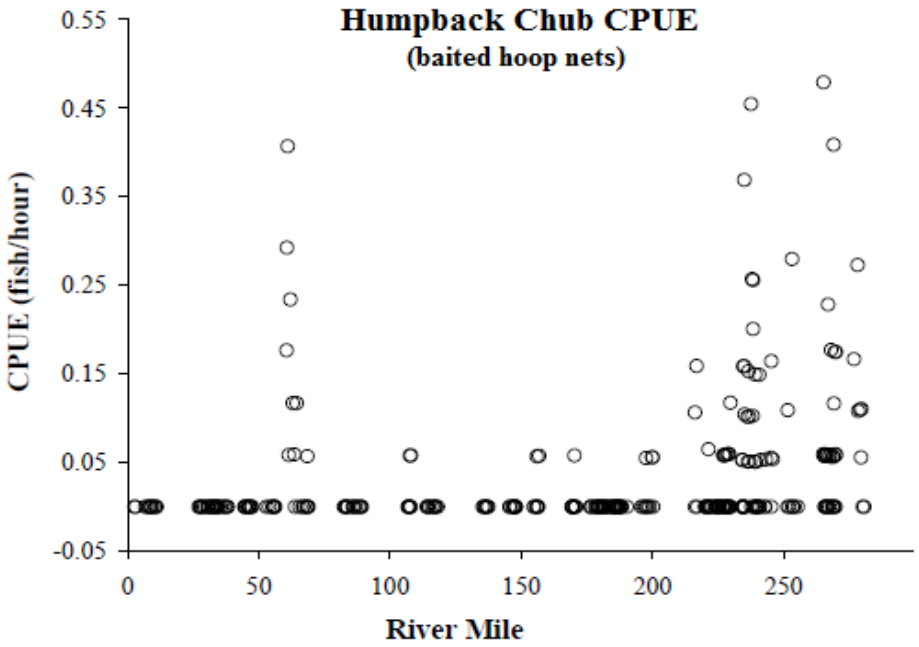


Figure 37. Humpback Chub mean catch per unit effort (CPUE; fish/hour) for baited hoop nets by river mile in 2016 (n = 319). Source: Rogowski et al. (2017).

Fish found recently in western Grand Canyon may have originated from spawning in the mainstem or in tributaries such as Havasu Creek. Evidence of reproduction by translocated Humpback Chub was found in Havasu Creek in 2012-2017; ripe spawning males were captured in May 2012, and ripe males and females, as well as untagged juveniles were captured in May 2013 (Nelson et al. 2016; Personal communication Brian Healy, 2017). Also, 12 ripe males were captured in the mainstem Colorado River upstream of the mouth of Shinumo Creek in June 2015 (Healy et al. 2014a). Some Humpback Chub translocated to Shinumo and Havasu creeks have descended to the mainstem, where greater numbers of ripe fish are being found. A small amount of reproduction has also taken place with translocated fish upstream of natural falls 14 km up the LCR (Stone 2016). These positive responses by wild and translocated Humpback Chub in the Grand Canyon are signs of an expanding and increasing population as the result of active management (translocations of fish), as well as climate-related phenomena (warmer dam releases and receding lake levels).

Translocations—Since 2003, young Humpback Chub have been translocated from the LCR to tributaries in the Grand Canyon above chutes and waterfalls. These translocations followed an implementation plan in 2000 developed for establishing a second population of Humpback Chub in the Grand Canyon (Valdez et al. 2000). The plan identified establishing populations of Humpback Chub in one or more tributaries of the Grand Canyon, and in 2003, fish were translocated from the lower LCR to the LCR above Chute Falls (RK 16.2) for the purpose of expanding the population upstream into unoccupied habitat and to develop methods for translocating live fish. For the period 2003–2015, a total of 2,971 juvenile

Humpback Chub was translocated by the U.S. Fish and Wildlife Service to the LCR above Chute Falls (Table 16; Stone 2016).

Table 15. Numbers of Humpback Chub translocated from the LCR to tributaries in the Grand Canyon. All fish were captured as juveniles (~50–140 mm TL) from the LCR, held at the Southwestern Native Aquatic Resources and Recovery Center (SNARRC) in New Mexico for ~6 months, where they were treated for parasites and diseases, and then they were released in May or June. All fish were PIT tagged prior to release, except for the 1,150 fish in the LCR Upper Reach that were VIE-tagged in 2003–2005.

Year of Release	Shinumo Creek[a]	Havasu Creek[b]	LCR Above Chute Falls (RK 16.2)[c]
2003	--	--	283
2004	--	--	300
2005	--	--	567
2006	--	--	--
2007	--	--	--
2008	--	--	299
2009	300	--	194
2010	300	--	109
2011	300	243	96
2012	0	298	212
2013	200	300	303
2014	0	300	305
2014[d]	--	209	--
2015	--	300	303
Totals:	**1,100**	**1,650**	**2,971**

[a] Data from Healy et al. (2014a)
[b] Data from Nelson et al. (2016)
[c] All fish translocated to the LCR were released at RK 16.2, which is 2.2 km above Chute Falls (Data provided by D. Stone, U.S. Fish and Wildlife Service, August 1, 2016)
[d] The June 2014 translocation to Havasu Creek was done in lieu of a translocation to Shinumo Creek due to anticipated negative impacts from the Galahad Fire. In July and August 2014, large floods and a debris flow followed the fire and killed or displaced all fish in Shinumo Creek (Healy et al. 2014c)

The translocation of fish in the LCR was successful, and in 2009, the National Park Service (NPS) began translocating juvenile Humpback Chub from the LCR to Shinumo Creek that totaled ~1,100 fish by the year 2013 (Table 15; Healy et al. 2014a). Many fish survived and became residents of Shinumo Creek and some descended and augmented the mainstem aggregation; Spurgeon et al. (2015) found that at least 53% of translocated juvenile Humpback Chub left Shinumo (35% left within the first 25 days of translocation). But, in 2014, a series of large ash-laden floods and a debris flow followed a wildfire in the drainage and killed or displaced the fish to the mainstem, eliminating all Humpback Chub from this tributary (Healy et al. 2014c).

In 2011, the NPS also translocated juvenile Humpback Chub into Havasu Creek for a total of 1,650 by the year 2015 (Table 15). Many of these fish have survived and have a high growth rate similar to that of fish in the LCR. Evidence of reproduction is also found in Havasu Creek. Ten untagged fish less than 150 mm TL and 15 fish ranging in size from 150-210 were captured in October 2015, indicating that natural spawning is taking place in Havasu Creek (Nelson et al. 2016), and recruitment to maturity has been documented through October of 2016. The latest population estimate for Humpback Chub ≥ 150 mm TL in Havasu Creek in May, 2016 was 297 (95% C.I. 291 – 327) (Brian Healy, National Park Service, Personal Communication, September 2017). A second population in the mainstem, or in a second tributary (as with the LCR) would bring greater levels of resiliency and redundancy to this population of Humpback Chub.

The Grand Canyon population of Humpback Chub is self-sustained with a large core population and multiple dispersed aggregations, with additional evidence of expansion from warmer dam releases, exposed historical habitat, and recent translocations of fish to tributaries.

4.5.7 Sum of Adult Numbers—Altogether, there are ~16,050 adult Humpback Chub in the entire Colorado River System, as of the last comprehensive census of 2012 (Figure 38). This includes ~3,800 adults in the upper basin[11], or 24% of the total, and ~12,250 in the lower basin, or 76% of the total. There are also several thousand young in each population that vary annually in number depending on reproductive success and survival. Using the most recent population estimate for each population (with varying dates), the largest numbers of adults are in the Grand Canyon population (12,250), followed by Desolation/Gray canyons (1,672), Westwater Canyon (1,315), Black Rocks (404), Cataract Canyon (300), and DNM (Yampa River with a small number of individuals remaining).

The abundance of adults in populations of the upper basin, including Black Rocks, Westwater Canyon, and Desolation/Gray canyons has followed a similar pattern in which numbers were highest in 1998–2000 and declined to low but stable numbers starting in ~2007. In contrast, the number of adults in the Grand Canyon was lowest in 2001 and has continued to increase through 2012.

[11] Since 2007, mean sum of adults in the three upper basin populations with robust estimates is about 3,800, which is a period of apparent stability. The remaining two populations do not have recent robust estimates.

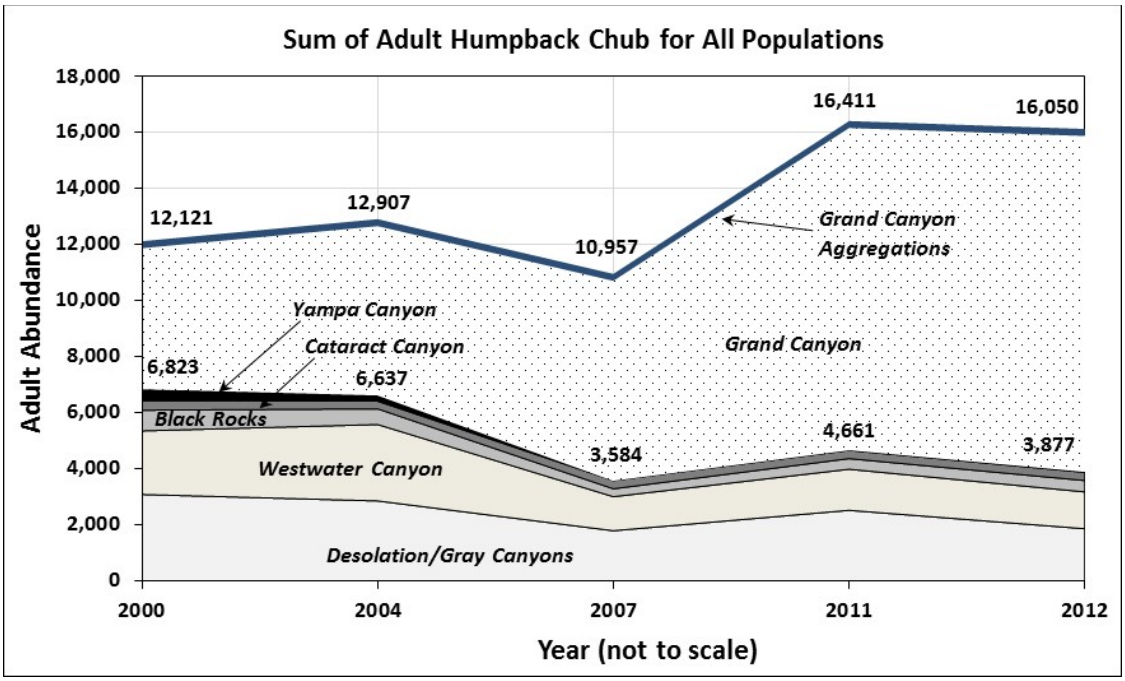


Figure 38. Cumulative sum of adult Humpback Chub for all populations in the census year. Estimates of adult abundance in the upper basin are not done every year, and values from the nearest year were used where estimates were not available. Note: dramatic increase in Grand Canyon populations may be misleading as estimates from 2000-2008 used an ASMR model which may be negatively biased.

5.0 FUTURE CONDITION

The assessment of current condition determined that stream flow and predation/competition are the key factors controlling upper basin populations; whereas, stream flow, water temperature, food supply, and predation/competition are the key factors for the lower basin population. Narratives in this section describe the probable future condition for these factors in the upper basin and lower basin. Section 5.1 defines a "biologically meaningful time frame" to place context on the span of time into which it is feasible to project future condition. Section 5.2 describes the risks and uncertainties in describing redundancy, resiliency, and representation for a biologically meaningful time frame. Section 5.3 describes the future condition of populations under three possible future scenarios that incorporate the uncertainty of the future, and this information is summarized in Tables 17, 18 and 19.

5.1 Biologically Meaningful Time Frame

The concept of a "biologically meaningful time frame" is used in this SSA to gauge the time span in which the population trajectory and status of the Humpback Chub can be reasonably predicted with consideration of ongoing and future management actions. To better understand this concept, we draw from the opinion of the Solicitor for the Department of the Interior in describing "The Meaning of 'Foreseeable Future' in Section 3(20) of the Endangered Species Act" (U.S. Department of the Interior 2009). "Foreseeable future" is the applicable time frame that is part of the definition of a threatened species from the ESA as *"…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S. C. § 1532(20)*.

Foreseeable future describes the extent to which the Service can, in making determinations about the future conservation status of a species, reasonably rely on predictions about the future. Those predictions can be in the form of extrapolation of population or threat trends, analysis of how threats will affect the status of the species, assessment of future events that will have a significant new impact on the species, and the efficacy of ongoing and future management actions. The Service's ability to rely on predictions may significantly vary with the amount and substance of available data and information.

Biologically meaningful time frame for the Humpback Chub is derived from generation time,[12] population trends, and the offsetting effect of management actions on threats. In the upper basin, generation time is derived from the age of female maturity of 5 years and average annual adult mortality of 0.33 (Howard and Caldwell 2017; Francis et al. 2016; Hines et al. 2016); i.e., 5 + (1/0.33) = 5 + 3 = 8 years. In Grand Canyon, longevity is artificially enhanced by cold temperature, and generation time is derived from an average age of maturity of 8 years (Yackulic et al. 2014) and an annual adult mortality of 0.13 (Coggins and Walters 2009); i.e., 8 + (1/0.13) = 8 + 8 = 16 years. This generation time is not applied to

[12] Generation time is defined as the average interval of time between the birth of parents and the birth of their offspring (Campbell et al. 1999).

the species elsewhere in the Colorado River System because the effect of cold dam releases affects only the Grand Canyon population.

Within this SSA, the viability of the species is evaluated a biologically meaningful timeframe of 16 years. A period of 8 years is used as the generation time for the Humpback Chub and as the time period in which changes in population trajectory are apparent (see section 4.5.5). Two generation times, or 16 years, is established as the short-term time frame, or the period of time in which population structure and demographics will enable populations to persist, with the help of ongoing threats management. The Science Advisory Subgroup evaluated the short-term timeframe, presented in Chapters 5 and 6.

To fully evaluate the potential risk to the species across longer timeframes, the U.S. Fish and Wildlife Service developed a means to consider the species condition up to 40 years into the future (Appendix C). This process provided consideration of the future condition of the species over additional generations, evaluated longer term changes in resource condition, and incorporated the uncertainty of a longer-term future.

5.2 Risks and Uncertainties

This species status assessment discusses several risks and uncertainties faced by the Humpback Chub in maintaining redundancy, resiliency, and representation for a biologically meaningful time frame. These risks fundamentally translate into species threats, which are incorporated into the future scenarios in Section 5.3 and may be considered in the species recovery plan. Some of these threats are overt, ongoing, and evident. Others are insidious and more uncertain as to their present and future effect on the species. The following summarizes these risks and uncertainties:

1. **Less Stream Flow—**All six populations of Humpback Chub are at risk from altered stream flow in the future. Significant surface-flow reductions are not expected, but periodic drought or groundwater withdrawals may further reduce flow. Episodes of drought have been seen in the last 6 decades. These episodes have led to higher air and water temperature, increased evaporative losses, and decreased stream flow. Decreased stream flow will reduce habitat, stress food supply, and exacerbate species inter-actions that can lead to increased predation and competition, as well as an increased likelihood of competition and hybridization with Roundtail Chub. The following describes risk management in the basins.
    a. In the upper basin, flow recommendations have been developed and are being applied (see Table 4 above), evaluated, and revised to provide a flow regime beneficial to the native fishes. Revised flow management provides Humpback Chub with more natural and consistent flow conditions, which is a great improvement from past decades, especially the early 2000 drought period.
    b. In the lower basin, flow of the Colorado River through the Grand Canyon is regulated by Glen Canyon Dam that is managed by the Law of the River and

the 2016 LTEMP EIS, which attempts to balance dam management with protection of resources, including the Humpback Chub.

Uncertainties exist as to the ability of stakeholders to provide current flow management actions into the future, thus impacting predictions of future stream flow conditions. A number of potential situations could decrease stakeholder ability to meet flow recommendations, such as increased demand on Colorado Basin Compact water and decreased supply from reduced water availability. Lack of legal protection for flows to benefit native fish decreases the certainty of flow management, although in many locations flow recommendations are codified under legal documents under NEPA or other agreements.

2. **Higher Water Temperature—**Warmer stream temperatures are evident throughout the Colorado River System for the last six decades. While warmer stream temperatures would likely have no impact, or beneficial impact, to Humpback Chub, warming stream temperatures increase the risk of nonnative fish establishing among Humpback Chub populations. The following describes the risk for the basins.

    a. In the upper basin, temperature-degree-days have increased with no apparent effect to Humpback Chub, but possibly better conditions for nonnative fishes. Increased frequency of below-average annual snowpack would increase the frequency of Smallmouth Bass production. Smallmouth Bass production outside of Humpback Chub populations increases the emigration of predatory individuals and increases the risk of establishment within areas occupied by Humpback Chub.

    b. Increased stream temperatures could increase the likelihood of Humpback Chub recolonizing Whirlpool Canyon if releases from Flaming Gorge Dam increase in temperature.

    c. In the lower basin, Humpback Chub have been able to maintain a population in the Colorado River despite cold dam releases by spawning in the seasonally-warmed LCR. Humpback Chub are able to reside in the cold mainstem, where body condition is enhanced, growth is slowed, and longevity is extended. Decreased stream flow is likely to result in lower levels of Lake Powell that will result in warmer downstream releases. Increased water temperature in the Grand Canyon could lead to improved food supply, but could also lead to increased abundance of Brown Trout, Green Sunfish, Smallmouth Bass, Walleye, and other cool and warm-water predators. Warmer water can also lead to an increase in mainstem spawning of Humpback Chub and increased growth of individuals—if food supply is suitable.

Uncertainties exist as to the response of nonnative fish to warmer stream flow conditions. Nonnative fish may not expand their range in response to warmer conditions, but instead be limited by habitat availability. Conversely, warmer stream flow conditions may allow nonnative fish to expand their ranges and increase their occurrence with Humpback Chub, especially Smallmouth Bass in the upper basin and

Green Sunfish and Smallmouth Bass in the lower basin. Independent of nonnative fish concerns, warmer stream temperatures are likely beneficial to Humpback Chub, especially in locations near dams such as Glen Canyon and Flaming Gorge.

3. **Pumping from the Coconino Aquifer—**Considerable groundwater is pumped from the Coconino aquifer that underlies the LCR Basin in north-central Arizona. Pumping from this aquifer could reduce stream volume of:

    a. The Blue Springs complex and reduce flow in the lower 18 km of the LCR that is currently a critical component of Humpback Chub habitat in the Grand Canyon; and

    b. Havasu Springs that discharges into Havasu Creek where Humpback Chub have recently been successfully translocated, with subsequent evidence of reproduction and recruitment.

    Uncertainties exist as to the likelihood and extent of any pumping from the Coconino Aquifer, but based on past data, it is anticipated that groundwater levels will continue to drop, potentially negatively impacting the base flow of the LCR.

4. **Parasites and Diseases—**Parasites and diseases generally do not pose a large risk to the Humpback Chub. The following summarizes this risk to the species by basin.

    a. In the upper basin, parasites and diseases do not appear to pose a significant threat to Humpback Chub.

    b. In the lower basin, the Asian tapeworm is common in the LCR, and is carried by infected fish into the mainstem where warming temperatures could enable this parasite to complete its life history. Fish being translocated to other locales from the LCR are being cleansed of parasites and diseases before the fish are released into the wild.

    Uncertainties exist as to the introduction of a new parasite or disease into Humpback Chub populations, although the likelihood of this introduction is currently believed to be quite low.

5. **Predation and Competition by Nonnative Fish—**Eighteen species of nonnative predators and competitors currently occur with the Humpback Chub. Most notable are Smallmouth Bass, Channel Catfish, Largemouth Bass, Walleye, and Northern Pike (see section 4.1.4). Densities of these nonnative fish in Humpback Chub habitat vary based on ecological conditions, with the most concerning being Smallmouth Bass. Because densities of these nonnative fish are either not meaningful (Walleye and Northern Pike), low (Largemouth Bass), unchanged for almost a century (Channel Catfish), or cyclical (Smallmouth Bass), we hypothesize that the arduous canyon habitats are effectively reducing colonization of these fish. Although actions to control nonnative fish basin-wide are removing large number of fish and suppressing

densities, the long-term efficacy of these efforts remains uncertain. The following are specific areas where this risk poses a threat to the species.

a. Smallmouth Bass, Northern Pike, and Channel Catfish are predaceous introduced fishes which have established reproducing populations in certain locations in the upper Colorado River System. Walleye and Largemouth Bass are predaceous introduced fishes that exist in the river primarily from emigrating from reservoirs (or ponds).

b. Channel Catfish reside and recruit in Humpback Chub population areas; Smallmouth Bass occur in a subset of Humpback Chub population areas but rarely recruit there; Largemouth Bass can occur and do not recruit in Humpback Chub population areas; Northern Pike and Walleye are rare or absent from Humpback Chub population areas.

c. Smallmouth bass are common in Desolation Canyon and have apparently expanded their range downstream throughout the canyon over the last decade, are present in low densities in the Dinosaur National Monument and Black Rocks populations, and are rare in other Humpback Chub populations.

d. Smallmouth Bass density and size structure in canyon habitats are influenced by upstream production rather than local production.

e. Rainbow Trout and Brown Trout reside in the Colorado River in Grand Canyon, and Green Sunfish, Smallmouth Bass, and Walleye potentially could expand there.

f. Channel Catfish, Green Sunfish, and Common Carp reside in the LCR.

Two primary uncertainties surround the relationship between Humpback Chub and nonnative fish. First, the effectiveness of management actions to control nonnative fish in the upper basin is unknown. Although actions are guided by robust scientific evaluation, are funded and implemented at near-maximum capacity, and are accomplished at an immense geographic scale, we cannot claim that the actions are assured to reduce the threat of nonnative fish. Current management techniques may simply be inadequate. Second, the canyons inhabited by Humpback chub may not be as resistant to colonization of Smallmouth Bass as we believe them to be. Currently, our best scientific judgment indicates that both management actions are appropriate and Humpback Chub habitats are resistant to colonization. However, we cannot ignore the uncertainty of these beliefs.

6. **Water Quality and Contaminants—**A number of contaminants enter the Colorado River on a regular basis from municipal, agricultural, and industrial sources, but the susceptibility of the Humpback Chub to these contaminants is undetermined. The following are specific areas where this risk poses a threat to the species.

a. Agricultural pesticides, pharmaceutical drugs such as immune suppressants and hormones, various industrial chemicals, heavy metals, and petroleum products accumulated from throughout the basin.

b. Selenium from Mancos shale in the upper basin.

c. Mercury from local emissions, such as coal-fired power plants, and from air-borne fallout.

The impact of municipal, agricultural, and industrial contaminants in populations of Humpback Chub is highly uncertain. At this time we have no data to indicate that these contaminants are a large impact to the species, but new information could change that hypothesis.

7. **Catastrophic Events—**Catastrophic events are natural or human-related phenomena that can kill or displace fish, or impose severe stress on a population, all of which can lead to short-term or long-term population decline. The following are potential and actual catastrophic events that may kill or displace Humpback Chub.

   a. Large ash-laden floods following wild fires and heavy rainstorms. These have occurred in Westwater Canyon and Desolation/Gray canyons of the upper basin, and in Shinumo Creek in the Grand Canyon.

   b. Petroleum pipeline ruptures. An oil spill occurred in the Yampa River from a petroleum product pipeline ruptured that released an unknown volume of material into the river with unknown effect to the native fish populations.

   c. Petroleum well rupture. A petroleum well ruptured near the Green River that released material into the Desolation/Gray canyons area with unknown effect.

   d. Riverside railways that carry various toxic materials run parallel to the Colorado River at Black Rocks and Westwater Canyon.

   e. Petroleum product pipelines that cross rivers or are within the 100-year floodplain.

   f. Spills from overland trucking, such as from the U.S. Highway 89 Bridge at Cameron, AZ on the LCR.

   It is uncertain how likely a catastrophic event is to occur and the impact of a spill on humpback chub would depend on the substance. At this time, it appears unlikely that a catastrophic event would take place, considering standard safety protocols. Moreover, the existence of multiple populations of Humpback Chub mitigates this impact.

8. **Reduced Genetic Diversity—**The genetic diversity of five of the six populations of Humpback Chub appears to be relatively high and stable (except for DNM). The following cast some uncertainty on the long-term genetic diversity of the species.

a. Glen Canyon Dam has separated the upper basin populations from the lower basin since 1963, with no chance of natural movement or exchange of individuals or genetic material. Although this isolation does not appear to have had a detrimental effect on genetic diversity, some genetic drift would be expected with time, and the genetic status of these populations should continue to be monitored.

b. Small populations are more subject to the loss of genetic diversity, such as seen with the DNM population.

c. Hybridization of Humpback Chub with Roundtail Chub and possibly Bonytail in the upper basin could exacerbate loss of alleles and adaptive traits. This could affect representation of the species, especially in the upper basin, and it may be prudent to investigate strategies for ensuring genetic diversity and viability in both the upper and lower basins.

9. **Population Trajectories—**Humpback Chub population trajectory is important for understanding species viability, but is uncertain for the upper basin populations.

    a. One population in the upper basin, Dinosaur National Monument, is below detection limits and is considered functionally extirpated.

    b. The numbers of adult abundance estimates for two of the five populations of Humpback Chub in the upper basin are too few and varied for a reliable projection of population trajectory.

    c. For populations where numbers of fish are sufficient and estimates are reliable (Black Rocks and Westwater Canyon), the time period of estimates appears to span only a part of the demographic cycle.

    d. CPUE indices that span a longer time period and that precede abundance estimates remain relatively consistent, but current estimates are insufficient to confirm this pattern.

    e. For the other upper basin populations, abundance estimates are too varied (Desolation/Gray canyons), numbers of fish are low (Cataract Canyon), or fish are nearly absent (DNM), and little can be said of the trajectory of these populations.

    f. Age-specific vital rates (e.g., survival, recruitment, growth) are not available to conduct a population viability analysis (PVA) for upper basin populations.

    g. For the Grand Canyon population, however, adult abundance estimates appear to show a complete demographic cycle, and vital rates are sufficient to understand that the population is on a stable trajectory.

Evaluating the population trajectories of Humpback Chub includes many sources of uncertainty, including sampling bias. For a long-lived species such as Humpback

Chub, evaluating population changes as either meaningful indices of change or as natural variability often requires long, robust datasets. This data exists in the Grand Canyon, but data in the upper basin is more infrequent and includes fewer captures. Recently, upper basin populations have apparently seen a measurable decline from the early 2000s, and potentially those declines have recently been arrested. However, without prolonged monitoring we cannot conclude with certainty if these populations are responding to management or experiencing natural variation in population dynamics.

10. **Efficacy and Intensity of Management Actions**—Conservation of the Humpback Chub is being coordinated by three principal programs that consist of stakeholders from federal, state, private, and tribal interests (see section 4.4). These programs are largely federally funded and renewed on a periodic basis. The programs implement and maintain actions vital for offsetting species threats and contributing to species recovery. Support and funding for these programs can be uncertain, depending on species status and trajectories, environmental conditions, and the current administrative and political atmosphere.

    The following is an overview of these programs.

    a. The Upper Colorado River Endangered Fish Recovery Program has been in place since 1988 and coordinates recovery for the Colorado Pikeminnow, Humpback Chub, Razorback Sucker, and Bonytail in the upper basin. The Program is currently funded through September 30, 2019 (with anticipation that funding will be extended through 2023).

    b. The Glen Canyon Dam Adaptive Management Program was established in 1997 with the Grand Canyon Protection Act, and is a Federal Advisory Committee with biennial funding renewal.

    c. The Lower Colorado River Multi-Species Conservation Program was implemented in 2005 and is funded annually.

    Two primary uncertainties surround the current management actions considered previously in this document: continued implementation of the actions; and effectiveness of the actions. Commitment to future funding and implementation of stakeholder management for the benefit of Humpback Chub is strong among the various partnerships. However, some of these Programs are not funded over the entire biologically meaningful timeframe analyzed here. Encouragingly, some specific management actions would remain in place, even without these programs, such as flow management analyzed under NEPA. However, other actions, most notably nonnative fish removal would not necessarily be continued without the programs. Even if programs continue in their current form and funding level, effectiveness of some management actions is uncertain. As previously discussed, both stream flow management and nonnative fish management may not have the desired effect on

Humpback Chub if water is unavailable or if nonnative fish management is ineffective.

11. **Reduced Water Availability**—Future manifestations of reduced water availability remain one of the biggest uncertainties for the hydrology of the Colorado River System. Shifts in hydrology and temperature in the last few decades may be a new long-term condition or may be within the range of system variability. These shifts have resulted in warmer water temperature, increased evaporation, reduced stream flow, and a shift from winter snow storage to spring snow/rain mix. All projections indicate that this pattern is likely to continue. The biggest future effect on the Humpback Chub will be an increased frequency of drought episodes, characterized as multiple consecutive years of low spring flow. This condition appears to reduce reproduction and recruitment in populations, and allows expansion of nonnative fish and Roundtail Chub into upper basin populations. Reduced annual river volume will also lower the elevation of Lake Powell and increase dam release temperature in the Grand Canyon, with a consequent potential increase in nonnative fish, such as brown trout (Al-Chokhachy et al. 2016).

5.3 Future Condition of Populations

The future condition of the Humpback Chub over the biologically meaningful timeframe of 16 years is expected to be driven largely by streamflow, stream temperature, and population dynamics of nonnative fish, although other resource conditions are important. Management actions for specific resource conditions further influence the future condition of the species. The UCRRP, GCDAMP, and LCR MSCP have implemented a suite of actions that improve resource conditions, especially stream flow, stream temperature, and impacts from nonnative fish; these actions ameliorate human effects as well as effects of reduced water availability and help to conserve the suite of native species that inhabit this region of the Colorado River.

Flow and temperature of the Colorado River System have been influenced for the last century by human activities that have regulated hydrology basin-wide and altered river temperature in short reaches below impoundments. This reduced flow and altered temperature have been exacerbated in the last 5-6 decades by periods of drought. These periods are marked by reduced stream flow, increased air temperature, and enhanced evaporation that are likely to continue and result in a number of ecological consequences, including, but not limited to reduced habitat availability, increased abundance and expansion of nonnative predaceous and competitive fish species, altered food supplies, and shifts in reproductive timing. Flow and temperature recommendations have been developed for the major rivers of the upper basin (Table 4), and even more importantly these recommendations have been applied. In the Grand Canyon, Glen Canyon Dam releases are coordinated through operating criteria in the LTEMP EIS (U.S. Department of the Interior 2016) and in the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and

Lake Mead EIS (U.S. Department of the Interior 2007). A temperature control device, installed on Flaming Gorge Dam in 1978, has warmed downstream releases for the Green River and allowed for upstream expansion of native fishes into Lodore Canyon (Bestgen et al. 2006). This warming could provide more suitable conditions for reestablishment of the Humpback Chub population in Whirlpool Canyon. In the lower basin, the Bureau of Reclamation has implemented feasibility studies for warming releases from Glen Canyon Dam. Warmer releases from the dam starting in 2004 have provided insight to possible beneficial effects of warming on native fishes in Grand Canyon, but warming could also benefit the nonnative fishes.

The UCRRP and its partners currently remove problematic nonnative fish species from nine river reaches of the upper basin on the Yampa, Green, Colorado, White, Duchesne, and Gunnison rivers (Tables 8 and 9). The species targeted for removal include: Smallmouth Bass, Northern Pike, Channel Catfish, Largemouth Bass, and Walleye, although other nonnative species are also removed as encountered. Removal efforts are adjusted annually to account for species ranges, densities, and environmental conditions. A Nonnative Fish Control Environmental Assessment was implemented in the Grand Canyon in 2012 to help conserve native fish, particularly the Humpback Chub, by taking necessary actions to reduce numbers of nonnative fish, especially Rainbow Trout and Brown Trout in the Colorado River downstream of Glen Canyon Dam (U.S. Department of the Interior 2011). Efforts to mechanically remove nonnative fish were effective, but these target species recovered quickly after removal was suspended (Coggins 2008). The 2016 LTEMP EIS (U.S. Department of the Interior 2016) and the 2013 Comprehensive Fisheries Management Plan (National Park Service 2013) help to define future actions for controlling nonnative fish in the Grand Canyon. Although mechanical nonnative fish control strategies are in place in Grand Canyon, it is uncertain if mechanical removal in the mainstem Colorado River would be effective during large Rainbow Trout recruitment years, and/or if Brown Trout increase in abundance in Glen Canyon and other areas and expand into the LCR inflow area.

As described in section 5.2, there are important uncertainties to consider about the future of resource needs for Humpback Chub and how management actions will impact those conditions. To assess possible future condition, the U.S. Fish and Wildlife Service selected three possible future scenarios of ecological conditions. The scenarios included varying implementation and effectiveness of active and adaptive management. The Science Advisory Team then evaluated the changes in ecological condition and resultant changes in resource conditions. Based on this evaluation, principal among the resource conditions impacting Humpback Chub are stream flow and temperature, and nonnative fish populations. It is important to note that all future scenarios assume that the risk from nonnatives will increase and availability of water will be lower (see Appendix B).

- Scenario 1 [Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated]—includes an elimination of some active and adaptive actions, and a reduction in voluntary management actions for the species, such that

many stakeholder actions are no longer in place to mitigate future conditions including decreased water availability, future water development, or nonnative fish. Conservation actions codified under binding agreements (NEPA, Section 7) would continue. For example, instream flows are not legally protected any more than they are today (e.g. RODs, PBOs remain in effect), some voluntary flow management actions diminish, and nonnative fish management is not continued in the Upper Basin. In the Lower Basin, water management, nonnative fish control, and other actions would remain consistent with the current level of effort prescribed by various RODs and ESA section 7 consultations, but no new or adaptive actions would take place. Although a greater proportion of actions in the Lower Basin are legally required, in this scenario it is expected that management actions are not adaptive or effective and are unable to respond to impacts from various stressors causing population declines of Humpback Chub in both basins.

- Scenario 2 [Legally Mandated Management Actions and Additional Adaptive Management Actions Occur, but are Ineffective]—in addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies' management practices occur into the future for the species, but these actions are ineffective to mitigate impacts of drought, future water development, nonnative fishes, or other threats. For example, water operations cannot provide adequate flows or temperatures in humpback chub habitats because drought or other factors have decreased water supply, or nonnative fish colonize Humpback Chub habitat in high densities despite stakeholder action. In this scenario, it is expected that management actions respond to the impacts from various stressors but are not effective to prevent Humpback Chub declines.

- Scenario 3 [Legally Mandated Management Actions and Adaptive Management Actions Occur, and Are Effective]—in addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies' management practices occur into the future for the species, and these actions are sufficient to mitigate impacts of drought, future water development, nonnative fishes, or other threats. For example, water operations have the flexibility to provide adequate flows and temperatures to and nonnative fish do not colonize or are effectively managed in Humpback Chub habitat. In this scenario, it is expected that management actions respond to the impacts from various stressors causing population declines, and are adequate to stabilize and increase Humpback Chub populations.

For each of the potential future scenarios, the overall effect expected to occur within each population is described below and then summarized in Tables 16, 17 and 18 for Scenarios 1, 2, and 3 respectfully.

5.3.1 Scenario 1: Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated

Black Rocks—The Black Rocks population represents a dense (~400 chub per mile) grouping of Humpback Chub, occupying a small reach of the upper basin where the Colorado River has carved a channel through an upthrust of Precambrian schist and gneiss. This formation is hard and resistant to short-term erosion and is likely to persist for many years with or without active management, although some encroachment from nonnative tamarisk may occur.

Reduced stream flows caused by reduced snowpack would not be actively managed and would result in low water conditions, especially in late summer. Reclamation's ROD at the Aspinall Unit and other long-term flow commitments protect against extreme low flows, but voluntary flow management in the upper Colorado River (upstream of the confluence with the Gunnison River) could diminish. The deep canyon habitats would concentrate water, limiting direct effects, but possibly reduce movement outside the population. River temperature is expected to warm, but the effect on fish is not expected to be measureable. The food supply is reliable and is expected to continue to be suitable into the future, but may be impacted by drying conditions.

Predation/competition from nonnative fish would be the greatest future threat for this population, which would be exacerbated by warming river temperatures, especially for Smallmouth Bass. Reduced management of nonnative fish both above and below the canyon habitats would increase pressure from nonnative fish in the canyons themselves. Reduced flow may encourage establishment of a nonnative predator, which would severely stress the population and reduce recruitment in the population. The risk for increase and expansion of nonnative fish is greatest in consecutive years of low flow which would occur more often without management.

Westwater Canyon—The Westwater Canyon population is the second largest population in the upper basin and represents a dense (~400 chub per mile) grouping of Humpback Chub. This population is found in a deep canyon with confined walls, where the river has carved through Precambrian schist and gneiss. The canyon is a popular whitewater rafting area that is managed, and will continue to be protected, by the Bureau of Land Management, although some encroachment from nonnative tamarisk may occur.

Reduced stream flow and increased temperature have similar effect as in Black Rocks, and the food supply appears suitable and stable into the future. Reclamation's ROD at the Aspinall Unit and other long-term flow commitments protect against extreme low flows. Voluntary flow management in the upper Colorado River (upstream of the confluence with the Gunnison River) could diminish. Reduced stream flows caused by reduced snowpack would not be actively managed and would result in low water conditions, especially in late summer. The deep canyon habitats would concentrate water, limiting the negative effects of flow. Movement between populations other than Black Rocks may be limited by reductions in flow.

As in Black Rocks, predation/competition from nonnative fish could be the greatest future threat to this population, which would be exacerbated by increasing temperatures. Reduced management of nonnative fish both above and below the canyon habitats would increase pressure from nonnative fish in the canyons themselves. Reduced flow may encourage establishment of a nonnative predator, which would severely stress the populations. The risk for increase and expansion of nonnative fish is greatest in consecutive years of low flow which would occur more often without management.

Desolation/Gray Canyons—The Desolation/Gray canyons population is the largest population in the upper basin. Humpback chub, in moderate densities, occupy the largest reach of the Green River through two canyons confined by high talus slopes and characterized by deep pools, large eddies, and rapids. The canyon is a popular whitewater rafting area that is managed, and will continue to be protected, by the Bureau of Land Management and the Ute Tribe, although some encroachment from nonnative tamarisk may occur.

Reduced stream flow would increase without active management because flows are heavily impacted by upstream reservoir operations. Operation of Flaming Gorge would continue under the 2006 ROD, which would prevent catastrophic low flows. Increases in water demand or decreases in water supply could limit the operation Flaming Gorge to primarily drier hydrologic conditions, which would improve conditions for Smallmouth Bass in nearby habitats.

The risk from predation/competition by nonnative fish would increase substantially, because Smallmouth Bass have already recently increased in range within Desolation/Gray canyons. Smallmouth Bass would likely establish resident populations, severely limiting recruitment in the Humpback Chub population. Without management, this trend would likely continue and threaten the persistence of the population.

Cataract Canyon—The Cataract Canyon population is the smallest extant population of Humpback Chub. The canyon habitat, administered by the National Park Service, is likely protected from future modifications. In fact, increased drought may continue to decrease the water level in Lake Powell, exposing more habitat for colonization.

Located below the confluence of the Colorado and Green rivers, Cataract Canyon water supply is the most consistent of all Humpback Chub populations. Flow management does impact flows in the canyon, but not to the degree of others in the Upper Basin. Individual basin snowpack variability is dampened by its downstream location; therefore removal of management would have a relatively small impact on this population. Also the severe hydrological conditions of Cataract Canyon may limit abundance of all fish species, provide an ample supply of food, and dampen the effect of drought. Little management of nonnative

fish currently exists in this population because nonnatives (primarily Walleye) appear to only migrate through Cataract Canyons.

The primary risk in this population is its small size, which is more vulnerable to stochastic extinction events. Without management, dramatic reductions in population size could go unnoticed and unaddressed.

Dinosaur National Monument.—The population of DNM which previously inhabited Yampa and Whirlpool Canyons, is currently below detection limits and is considered functionally extirpated. Without active management, such as a translocation or introduction effort, this population will remain extirpated. Some species needs may remain in acceptable conditions despite the absence of Humpback Chub. Canyon habitat will continue to be protected by the National Park Service, including management against nonnative tamarisk.

Occurrence of reduced stream flows would increase in Yampa Canyon without active management because flows are heavily impacted by upstream water use. Extreme low flow conditions would likely exist, as they did in the early 2000s prior to water management. Any fish that did recolonize the area of Yampa Canyon could be extirpated under these low flows. Stream flow would decrease in Whirlpool Canyon without active management, but extreme low flows would be prevented by Flaming Gorge Dam operations. Operation of Flaming Gorge would continue under the 2006 ROD (U.S. Department of the Interior 2006), which would prevent catastrophic low flows. Increases in water demand or decreases in water supply could limit the Flaming Gorge operation to primarily drier hydrology conditions.

Predation/competition from nonnative fish could be the greatest future threat to this population. Reduced management of nonnative fish both above and below the canyon habitats would increase pressure from nonnative fish in the canyons themselves. Reduced flow would increase nearby production and may encourage establishment of a nonnative predator, which would severely stress the populations. In previous low flow years, smallmouth bass have increased to ~10% of the fish community; this percentage could be higher under scenario 1. The risk for increase and expansion of nonnative fish is greatest in consecutive years of low flow which would occur more often without management.

The combination of these threats makes reestablishment of a functional population highly unlikely.

Grand Canyon—The Grand Canyon population is the largest population of Humpback Chub. The physical habitat is largely intact, and available sediment will continue to be managed by flow agreements already in place. The future flow regime is described in the 2016 LTEMP EIS (U.S. Department of the Interior 2016), in which GCD releases are designed to benefit canyon resources. Future river temperature is somewhat uncertain. If drought continues and Lake Powell continues to drop in elevation, warm dam releases will

continue during the fall, with consequent potential effects including increased abundance and distribution of nonnative fish. The food base is in poor condition and would be expected to worsen without active management.

Predation/competition by Rainbow Trout and Brown Trout is likely to continue, and without management, could begin to dramatically impact the population. Alternatively, warming conditions could promote the establishment of a new nonnative predator. Smallmouth Bass, Walleye, or other nonnatives may expand in numbers and distribution and lead to more predation on young Humpback Chub. Catastrophic events may continue to affect tributaries, if conditions such as wild fires are followed by heavy rainstorms and ash-laden floods or debris flows. Impediment to movement between the upper and lower basins will persist with the presence of Glen Canyon Dam, and it may be necessary at some future time to mix fish across basins.

Perhaps the least recognized future threat to the Grand Canyon population is continued pumping of water from the Coconino aquifer, which is the source of water for base flow of the LCR and Havasu Creek. Effects of groundwater pumping are largely unknown.

Populations are likely to continue to reproduce and recruit, but numbers may be reduced. The current population size protects from a variety of potential threats.

Table 16. A summary of the future condition of species needs under Scenario 1 for the six populations of the Humpback Chub. Color codes: dark green = resource condition is good, light green = fair; yellow = neutral; orange = poor; red = bad.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
1. Diverse rocky canyon river habitat	**Good** • Physical habitat of optimal condition. • Intact, protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Good** • Physical habitat of optimal condition. • Intact, protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches . • Protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches . • Protected and likely to persist. • Some encroachment by nonnative vegetation armors cobble bars and limits spawning	**Good** • Physical habitat of optimal condition. • Largely intact, available sediment managed by flow.
2a. Suitable flow	**Poor** • Water availability and lack of adaptive management could dramatically reduce flows suitable for Humpback Chub. • Reclamation's ROD at the Aspinall Unit and other long term flow commitments protect against catastrophic low flows.	**Poor** • Water availability and lack of adaptive management could dramatically reduce flows suitable for Humpback Chub. • Reclamation's ROD at the Aspinall Unit and other long term flow commitments protect against catastrophic low flows.	**Poor** • Water availability and lack of adaptive management could dramatically reduce flows suitable for Humpback Chub. • Flaming Gorge operation under 2006 ROD would prevent catastrophic low flows.	**Neutral** • Water availability and lack of adaptive management could dramatically reduce flows suitable for Humpback Chub. • Extreme downstream location mitigates variability of water supply for smaller basins.	**Bad** • Water availability and lack of adaptive management could dramatically reduce flows suitable for Humpback Chub. • Drought conditions could create catastrophic low flows in Yampa Canyon. • Flaming Gorge operation under 2006 ROD would prevent catastrophic low flow in Whirlpool Canyon.	**Neutral** • LTEMP EIS and GCD[a] releases would continue. • Drought could reduce levels in Lake Powell which may restrict flow options under the LTEMP EIS. • Interstate and international agreements require certain flows be delivered downstream.
2b. Suitable temperature	**Neutral** • Temperature is expected to warm, but direct effects on Humpback Chub are not expected.	**Neutral** • Temperature is expected to warm, but direct effects on Humpback Chub are not expected.	**Neutral** • Temperature is expected to warm, but direct effects on Humpback Chub are not expected.	**Neutral** • Temperature is expected to warm, but direct effects on Humpback Chub are not expected.	**Neutral** • Temperature is expected to warm, but direct effects on Humpback Chub are not expected.	**Fair** • Drought-induced low level of Lake Powell likely to result in warmer water releases. • Cold releases from GCD possible but less likely. • Temperature Control Device on GCD will not occur.
3. Adequate and reliable food supply	**Fair** • Food supply is expected to persist, though may be altered by increasing temperatures and decreasing flows.	**Fair** • Food supply is expected to persist, though may be altered by increasing temperatures and decreasing flows.	**Fair** • Food supply is expected to persist, though may be altered by increasing temperatures and decreasing flows.	**Fair** • Food supply is expected to persist, though may be altered by increasing temperatures and decreasing flows.	**Fair** • Food supply is expected to persist, though may be altered by increasing temperatures and decreasing flows.	**Bad** • Food supply is likely to diminish from its current condition, with only substandard items remaining.
4. Habitat with few nonnative predators and competitors	**Bad** • Established nonnative fish populations above and below canyon would expand into Humpback Chub areas and management would not respond. • Invasion of a new predatory species could cause serious predation/ competition effects.	**Poor** • Established nonnative fish populations above and below canyon would expand into Humpback Chub areas and management would not respond. • Invasion of a new predatory species could cause serious predation/ competition effects.	**Bad** • Established nonnative fish populations above and below canyon would expand into Humpback Chub areas and management would not respond. • Invasion of a new predatory species could cause serious predation/ competition effects.	**Neutral** • Invasion of a new nonnative species could cause serious effects from predation/ competition. • Location, habitat conditions and continued attempts at management likely to prevent severe impacts in this population.	**Bad** • Established nonnative fish populations above and below canyon would expand into Humpback Chub areas and management would not respond. • Invasion of a new predatory species could cause serious predation/ competition effects.	**Poor** • Invasion of an unmanageable species could cause serious effects from predation/ competition. • Nonnatives outside LCR aggregation unlikely to be managed.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
Habitat with few nonnative predators and competitors (continued)	• Increased temperature would benefit Smallmouth Bass production nearby.	• Increased temperature would benefit Smallmouth Bass production nearby.	• Increased temperature would benefit Smallmouth Bass production nearby.		• Increased temperature would benefit Smallmouth Bass production nearby.	• Redundant populations separated by barriers may prevent severe impacts. • Increased invasion possible as temperatures increase. • No new tools available to manage nonnatives.
5. Suitable water quality	**Poor—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Without active management, spills may go unnoticed or remain uncontained.	**Poor—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Without active management, spills may go unnoticed or remain uncontained.	**Poor—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Without active management, spills may go unnoticed or remain uncontained.	**Poor—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Without active management, spills may go unnoticed or remain uncontained.	**Poor—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Without active management, spills may go unnoticed or remain uncontained.	**Poor—Uncertain** • Effects of persistent contaminants on fish not well understood. • Without active management, spills may go unnoticed or remain uncontained. • Threat of spill at Cameron Bridge on LCR has been reduced.
6. Unimpeded range and connectivity	**Fair** • Without managed flows, movement between populations may be impeded. • Populations exist within close proximity, some movement likely to continue.	**Fair** • Without managed flows, movement between populations may be impeded. • Populations exist within close proximity, some movement likely to continue.	**Neutral** • Without managed flows, movement between populations may be impeded.	**Neutral** • Population not in close proximity to others.	**Poor** • Without managed flows, movement between populations may be impeded. • Population not in close proximity to others.	**Fair** • Movement maintained between mainstem & LCR. • Tributary barriers to fish passage are not expected to be modified for passage. • Impediment to movement between upper and lower basins will continue.
7. Persistent population	**Bad** • Poor flow and nonnative fish conditions are expected to severely limit recruitment. • Management unable to arrest declines resulting in elimination of at least one currently persisting population in the upper basin.	**Bad** • Poor flow and nonnative fish conditions are expected to severely limit recruitment. • Management unable to arrest declines resulting in elimination of at least one currently persisting population in the upper basin.	**Bad** • Poor flow and nonnative fish conditions are expected to severely limit recruitment. • Management unable to arrest declines resulting in elimination of at least one currently persisting population in the upper basin.	**Bad** • Small population size is more vulnerable to stochastic population collapse. • Management unable to arrest declines potentially eliminating population.	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to prevent the reestablishment of this population.	**Fair** • Core LCR population expected to continue to reproduce and recruit annually.
8. High genetic diversity	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to stress populations and reduce the number of individuals, threatening genetic diversity.	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to stress populations and reduce the number of individuals, threatening genetic diversity.	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to stress populations and reduce the number of individuals, threatening genetic diversity.	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to stress populations and reduce the number of individuals, threatening genetic diversity.	**Bad** • Effects from less than optimal flow conditions and nonnative fish are expected to stress populations and reduce the number of individuals, threatening genetic diversity.	**Neutral** • Populations are likely to suffer reductions with presence of unmanaged nonnative species, yet are likely to persist with genetically diverse individuals.

[a] GCD = Glen Canyon Dam

5.3.2 -Scenario 2: Legally Mandated Management Actions and Additional Adaptive Management Actions Occur, but are Ineffective

Black Rocks— Stakeholder commitment to management of this population will provide more flexibility and active response to poor resource conditions, such as streamflow and presence of nonnative fish. However, even with active flow management and nonnative fish removal, it is uncertain if water operations will have the flexibility to provide adequate flows in all years or if nonnative fish management will prevent colonization of Smallmouth Bass.

Reduced stream flows caused by reduced snowpack would be actively ameliorated through management and would result in less frequent low water conditions compared to scenario 1, but low flow years are expected to still occur. Reclamation's ROD at the Aspinall Unit (U.S. Department of the Interior 2012) and other long-term flow commitments protect against extreme low flows, but frequent years of low flow will still negatively impact the population. Substantial decrease in water availability, either from chronically reduced snowpack or increased water demand, could outstrip Reclamation's capacity to provide appropriate flow conditions.

Frequent low flow conditions and increased water temperature would benefit Smallmouth Bass production nearby. Continued management of nonnative fish both above and below the canyon habitats would reduce populations but would be unable to prevent establishment (or periods of establishment) of a nonnative predator, which would severely stress the population and slow recruitment. The risk for increase and expansion of nonnative fish is greatest in consecutive years of low flow which would occur even during flow management. Nonnative fish would likely colonize at lower densities than nearby reaches, but would impact a consistent, long-term impact on the population. The population is moderate in size and is expected to continue to reproduce and recruit annually, albeit likely in a declining state. Genetic diversity is expected to endure, and the population is likely to persist but decline under sub-standard resource conditions. Individual movement between Black Rocks and Westwater populations may assist in population stabilization.

Westwater Canyon— Resource conditions under scenario 2 are expected to be the same as in the Black Rocks population immediately upstream. The primary difference is the increased stream miles occupied by Humpback Chub in Westwater Canyon will likely improve population resilience and slow declines. Also, Westwater Canyon is further downstream from Smallmouth Bass production areas which may decrease the likelihood of colonization or density of establishment of this species.

Desolation/Gray Canyons— Stakeholder commitment to management of this population will provide more flexibility and active response to poor resource conditions, such as streamflow and increased densities of nonnative fish. However, even with active flow management there is uncertainty if Flaming Gorge operations will have the long-term water

supply to provide adequate flows in all years. Similarly, it is uncertainty if nonnative fish management will prevent long-term establishment of Smallmouth Bass that are currently expanding their range within the canyon.

Improved flow management over the last decade, combined with future protection of flows in the Green River, should assist in providing suitable conditions for a viable Humpback Chub population. Specifically, the Bureau of Reclamation re-operated Flaming Gorge dam in 2006 to implement flow and temperature recommendations for the endangered fish in the Green River (Muth et al. 2000). However, under certain chronically low snowpack conditions, Flaming Gorge operations may need to operate in the drier hydrologies more frequently than are needed for Humpback Chub resource conditions. Peak and base flow operations intended to provide beneficial conditions for Humpback Chub in Desolation / Gray Canyons may not provide the variability needed over the long-term.

Increased frequency of drier hydrology operations is problematic in this population because Smallmouth Bass increase in density in upstream reaches during those years and then emigrate downstream in Desolation Canyon. Furthermore, Smallmouth Bass recently increased in range within Desolation/Gray canyons, and may establish a resident population if flow conditions allow. While densities of Smallmouth Bass have declined in response to flows not conducive to their production, Flaming Gorge operations may not be able to provide these flows consistently enough. Future nonnative fish removal and management will need to monitor the condition in this habitat and ensure that appropriate actions are taken. Unfortunately, it is uncertain if these actions are sufficient to prevent establishment of Smallmouth Bass in the Desolation Canyon population. Very little exchange of individuals with other population occurs, and it is unlikely that future demographic effects will extend to or from other populations. It is expected that genetic diversity will endure and that this population will persist but decline under this scenario.

Cataract Canyon— Stakeholder commitment to providing flows across multiple basins will likely provide adequate flows for this downstream location. Flows provided in the Colorado and Green rivers will support this population. Only under the most extreme basin-wide drought scenarios will flows not be adequate. However, more habitat will open as Lake Powell levels drop. It is unlikely that nonnative species from Lake Powell or upstream colonize this area. The severe hydrological conditions of Cataract Canyon—because it is located below the confluence of the Colorado and Green rivers—may limit the abundance of all fish species, provide an ample supply of food, and dampen the effect of drought.

However, the Cataract Canyon population is the smallest extant population of Humpback Chub, putting it at greatest risk from a stochastic disturbance or genetic impacts. Since it was reduced in distribution by the filling of Lake Powell, it has remained small. Nevertheless, this population is expected to continue to remain small and persistent under this scenario.

Dinosaur National Monument— The population of DNM, which previously inhabited Yampa and Whirlpool Canyons, is currently below detection limits and is considered functionally extirpated. Management actions can still provide adequate resource conditions that will support an introduction or translocation attempt. Flow and temperature regimes in the Yampa River are largely unregulated, reducing management control. Conversely, nearby Whirlpool Canyon on the Green River is highly controlled by the presence of Flaming Gorge Dam. Modified operations over the past decade, and a temperature control device on Flaming Gorge Dam provide more natural flows and warmer water for the Green River, and are expected to continue into the future. Similar to Desolation Canyon, under certain chronically low snowpack conditions, Flaming Gorge operations may need to operate in the drier hydrologies more frequently than are needed for Humpback Chub resource conditions and which may allow for increased immigration of Smallmouth Bass.

Flow management in Yampa Canyon is expected to improve conditions compared to previous decades that saw the Humpback Chub become extirpated. In 2007, the Recovery Program secured a permanent source of summer augmentation water (5000 acre-feet with an option to lease an additional 2000 acre-feet) in Elkhead Reservoir in the upper Yampa River drainage. The Recovery Program has used the permanent pool every year since 2007 to improve summer base flow conditions in the lower Yampa River, including Yampa Canyon. However, under extreme low flow conditions, this pool of water would be inadequate to supply the entire base flow condition needed by Humpback Chub.

Smallmouth Bass (primarily juvenile sized fish) can comprise as much as 10% of the Yampa Canyon fish community during and following years of high production upstream. Although the species has not colonized Yampa Canyon in high densities over the long term, as it has in adjacent reaches, chronically poor flow conditions could provide opportunity for long-term establishment. Significant efforts are underway to control spawning congregations of Smallmouth Bass in the Yampa River and to eliminate escapement from upstream reservoirs, but it is uncertain if these actions are sufficient to prevent colonization of Yampa and Whirlpool canyons if dry hydrologies become the norm. We expect under scenario 2, Smallmouth Bass density will likely be no more than 10%, but instances of this density will increase in frequency.

Under this scenario, reestablishment of a resident population remains unlikely.

Grand Canyon— The Grand Canyon population is the largest population of Humpback Chub, and is likely to continue to be self-sustained for 16 years with appropriate and effective threats management. The physical habitat is largely intact, and available sediment will continue to be managed by flow. The future flow regime is described in the 2016 LTEMP EIS (U.S. DEPARTMENT OF THE INTERIOR 2016), in which GCD releases are designed to benefit canyon resources. Future river temperature is somewhat uncertain. If drought continues and Lake Powell continues to drop in elevation, warm dam releases will continue during the months of August–October, with consequent potential

effects including increased abundance and distribution of nonnative fish. The future of the food supply is also uncertain, and ongoing research is attempting to determine the causes of low food supply and strategies for enhancing instream production.

Predation/competition by Rainbow Trout and Brown Trout is likely to continue, and research is ongoing to better understand management strategy. Stakeholders are collaborating on actions to control this and other potentially invasive species, such as Green Sunfish. Smallmouth Bass and Walleye may expand in numbers and distribution and lead to more predation on young Humpback Chub, if management actions are unable to avert an increase in these nonnative species. The threat of a spill at the Cameron Bridge seems to be reduced with reconstruction of U.S. Highway 89 and the bridge and interchange in that area. Catastrophic events may continue to affect tributaries, if conditions such as wild fires are followed by heavy rainstorms and ash-laden floods or debris flows. Impediment to movement between the upper and lower basins will persist with the presence of Glen Canyon Dam, and it may be necessary at some future time to mix fish across basins.

Movement of fish within the Colorado River in Grand Canyon is expected to continue unimpeded, and translocations of young fish into tributaries above falls and chutes should continue. The core LCR population is expected to continue to reproduce and recruit annually. Mainstem reproduction and recruitment is also expected with warmer water, and range expansion into western Grand Canyon is expected with exposed historical habitat from the receding levels of Lake Mead. This expansion in western Grand Canyon could lead to a second reproduction center of Humpback Chub in the lower basin. Genetic diversity is expected to persist. Pumping of water from the Coconino aquifer could affect populations in this scenario as well.

Table 17. A summary of the future condition of species needs under Scenario 2 for the six populations of the Humpback Chub. Color codes: dark green = resource condition is good; light green = fair; yellow = neutral; orange = poor; red = bad.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
1. Diverse rocky canyon river habitat	**Good** • Physical habitat of optimal condition' • Intact, protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Good** • Physical habitat of optimal condition. • Intact, protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist. • Some encroachment by nonnative tamarisk but immeasurable effect to habitat.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist. • Some encroachment by nonnative vegetation armors cobble bars and limits spawning.	**Good** • Physical habitat of optimal condition, largely intact, available sediment managed by flow.
2a. Suitable flow	**Neutral** • Extreme weather events, especially long term drought, reduce the ability to manage flows suitable for Humpback Chub. • Aspinall Unit operations under the ROD would not have adaptive flexibility to respond to extreme weather conditions.	**Neutral** • Extreme weather events, especially long term drought, reduce the ability to manage flows suitable for Humpback Chub • Aspinall Unit operations under the ROD would not have adaptive flexibility to respond to extreme weather conditions.	**Neutral** • Extreme weather events, especially long term drought, reduce the ability to manage flows suitable for Humpback Chub. • Flaming Gorge operations under the 2006 ROD would not have adaptive flexibility to respond to extreme weather conditions.	**Fair** • Extreme downstream location likely provides adequate flow from a combination of the basins.	**Poor** • Drought will contribute to flow reduction. • Low flow in Yampa River likely to recur which may be severe enough to overwhelm the surplus water managed by the UCRRP. • Flaming Gorge operations under the 2006 ROD would not have adaptive flexibility to respond to extreme weather conditions.	**Neutral** • Flow is determined by LTEMP EIS and GCD[a] releases designed to benefit canyon resources. • Possibility exists that drought could reduce levels in Lake Powell which may restrict flow options under the LTEMP EIS. • Interstate and international agreements require certain flows be delivered downstream.
2b. Suitable temperature	**Fair** • Temperature is expected to warm, but effect on Humpback Chub not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on Humpback Chub not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on Humpback Chub not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on Humpback Chub not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on Humpback Chub not expected to be measureable.	**Fair** • Drought induced low level of Lake Powell likely to result in warmer water releases. • Cold releases from GCD possible, but less likely as reservoir refilling or Temperature Control Device not expected in this time frame.
3. Adequate and reliable food supply	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Neutral** • Food supply may continue to be limited. • Management may not be able to increase food production.
4. Habitat with few nonnative predators and competitors	**Neutral** • Increased temperature would benefit Smallmouth Bass production nearby, increasing emigrating predators.	**Neutral** • Increased temperature would benefit Smallmouth Bass production nearby, increasing emigrating predators.	**Poor** • Invasion of Smallmouth Bass could greatly alter fish community. • Colonization of Smallmouth Bass likely slowed through flow	**Fair** • Invasion of a predatory species unlikely based on downstream location. • Location, habitat conditions and continued attempts at	**Poor** • Invasion of Smallmouth Bass could greatly alter fish community. • Colonization of Smallmouth Bass likely slowed through flow	**Neutral** • Invasion of an unmanageable species could cause serious effects from predation or competition.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
Habitat with few nonnative predators and competitors (continued)	• Populations likely still somewhat protected by nonnative removal actions and natural flow regimes. • Invasion of a new predatory species could cause serious effects.	• Populations likely still somewhat protected by nonnative removal actions and natural flow regimes. • Invasion of a new predatory species could cause serious effects.	and nonnative fish management actions. • Increased temperature would benefit Smallmouth Bass production nearby.	management likely to prevent impacts in this population.	and nonnative fish management actions. • Increased temperature would benefit Smallmouth Bass production nearby.	• Redundant populations separated by barriers may prevent severe impacts. • Additional tools available to manage nonnatives, but few effective.
5. Suitable water quality	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on fish not well understood. • Fish kills may continue in tributaries from ash-laden floods and debris flows after wild fires.
6. Unimpeded range and connectivity	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, and Redlands may expand upstream range.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, and Redlands may expand upstream range.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Tusher Wash may expand facilitate movement among populations.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, Redlands, and Tusher Wash may expand upstream range.	**Poor** • No impediment for movement to other populations in upper basin, but population seems too distant from others to recolonize.	**Fair** • Tributary barriers not expected to be modified for passage. • Translocations of young fish to new locations with mixed success.
7. Persistent population	**Neutral** • Effects from less than optimal flow conditions and nonnative fish are expected to limit recruitment. • Management expected to slow potential population declines. • Population likely to remain with support from Westwater.	**Neutral** • Effects from less than optimal flow conditions and nonnative fish are expected to limit recruitment. • Management expected to slow potential population declines. • Population likely to remain with support from Black Rocks.	**Poor** • Effects from less than optimal flow conditions and nonnative fish are expected limit recruitment.	**Poor** • Effects from less than optimal flow conditions and nonnative fish are expected to stress the population limit recruitment. • Small population size is more vulnerable to stochastic population collapse.	**Bad** • Effects from less than optimal flow conditions and nonnative fish may prevent successful translocation.	**Fair** • Core Little Colorado River population expected to continue to reproduce and recruit annually. • Mainstem reproduction and recruitment expected with warmer dam releases. • Aggregations outside LCR reduced if nonnatives expand and cannot be managed.
8. High genetic diversity	**Neutral** • Uncontrolled nonnative fish expected to stress populations and reduce the number of individuals. • Genetic diversity likely to remain with support from Westwater. • Genetic management actions expected when populations reach critical levels.	**Neutral** • Uncontrolled nonnative fish expected to stress populations and reduce the number of individuals. • Genetic diversity likely to remain with support from Black Rocks. • Genetic management actions expected when populations reach critical levels.	**Neutral** • Uncontrolled nonnative fish expected to stress populations and reduce the number of individuals. • Genetic diversity likely to remain with support from Cataract. • Genetic management actions expected when populations reach critical levels.	**Neutral** • Uncontrolled nonnative fish expected to stress populations and reduce the number of individuals. • Genetic diversity likely to remain with support from Deso/Gray. • Genetic management actions expected when populations reach critical levels.	**Bad** • Unsuccessful translocation does not contribute to genetic integrity of the species.	**Fair** • Populations are likely to persist with genetically diverse individuals. • Some sub-populations protected from nonnative fish invasions by physical structures.

[a] GCD = Glen Canyon Dam

5.3.3 - Scenario 3*:* Legally Mandated Management Actions and Adaptive Management Actions Occur, and Are Effective

Black Rocks—As in the above scenarios, the physical habitat is expected to remain unchanged. Reduced stream flow has affected this population since mainstem dam construction and increased water use, but little additional flow reduction is expected in the future, and is expected to be managed effectively in this scenario. The Bureau of Reclamation and other water managers are managing flows in the upper Colorado and the Gunnison rivers to meet flow recommendations (Osmundson et al. 1995; McAda 2003) for the endangered fish throughout the Upper Colorado subbasin including for Humpback Chub in Black Rocks and Westwater Canyon. River temperature is expected to warm slightly, but the effect on fish is not expected to be measureable. The food supply appears to be good and reliable and is expected to continue to be suitable into the future.

Predation/competition from nonnative fish could be the greatest future threat for this population, and the efficacy of nonnative fish management is vital, especially in years of low flow. The effect of water contaminants is not well understood, but emergency response plans and safety shutoff valves on pipelines will reduce the threat. There is no impediment for movement of individuals to other populations in the upper basin, and recent fish passage at Price-Stubb, Grand Valley, Government Highline, and Redlands may expand upstream range. The population is moderate in size and is expected to continue to reproduce and recruit annually. Despite a large number of Roundtail Chub in Black Rocks, genetic diversity is expected to endure, and the population is likely to persist for 16 years with appropriate and effective threats management.

Westwater Canyon—The Westwater Canyon population is the second largest population in the upper basin. The canyon is a popular whitewater rafting area that is managed, and will continue to be protected, by the Bureau of Land Management. Reduced stream flow and increased temperature have similar effect as in Black Rocks, and the food supply appears suitable and stable into the future. Improved water management will likely improve flow conditions in the future. More appropriate flow conditions in this habitat will therefore support a viable population.

As in Black Rocks, predation/competition from nonnative fish could be the greatest future threat and the efficacy of nonnative fish management is vital. However, despite high densities on nonnative fish in nearby reaches, densities in Westwater Canyon have not fundamentally changed over the past few decades. Consistent nonnative fish monitoring and management will likely help reduce the risk of nonnative fish colonization in this habitat, providing conditions for a viable population. There is no impediment to movement within or from this population, and there is exchange of individuals with the Black Rocks population. The future condition of resources in the Westwater Canyon population is similar to that of the Black Rocks population, and is expected to persist for 16 years with appropriate and effective threats management.

Desolation/Gray Canyons—The Desolation/Gray canyons population is the largest population in the upper basin. It occupies a large reach of the Green River through two canyons confined by high talus slopes and characterized by deep pools, large eddies, and rapids. The canyon is a popular whitewater rafting area that is managed, and will continue to be protected, by the Bureau of Land Management. Reduced stream flow and increased temperature will persist, but no additional effect to the population is expected, except during prolonged episodes of drought.

Improved flow management over the last decade, combined with future protection of flows in the Green River, should assist in providing suitable conditions for a viable Humpback Chub population. Specifically, the Bureau of Reclamation re-operated Flaming Gorge dam in 2006 to implement flow and temperature recommendations for the endangered fish in the Green River (Muth et al. 2000). Those operations promote inter- and intra-annual variability in accordance with a natural flow paradigm and protect flows from reaching extremes in drought years. Those peak and base flow operations are intended to provide beneficial conditions for Humpback Chub in Desolation/Gray canyons as well as for the other endangered species.

Predation/competition by nonnative fish is problematic in this population because Smallmouth Bass recently increased in range within Desolation/Gray canyons, unlike the Black Rocks and Westwater Canyon populations. While densities of Smallmouth Bass have declined in response to flows not conducive to their production, adults have established a more complete range with Desolation/Gray canyons. Future nonnative fish removal and management will need to monitor the condition in this habitat and ensure that appropriate actions are taken. Very little exchange of individuals with other population occurs, and it is unlikely that future demographic effects will extend to or from other populations. It is expected that genetic diversity will endure and that this population will persist for 16 years with appropriate and effective threats management.

Cataract Canyon—The Cataract Canyon population is the smallest extant population of Humpback Chub. Since it was reduced in distribution by the filling of Lake Powell, it has apparently remained small and is expected to persist into the future. The severe hydrological conditions of Cataract Canyon—because it is located below the confluence of the Colorado and Green rivers—may limit the abundance of all fish species, provide an ample supply of food, and dampen the effect of drought. While Walleye and Smallmouth Bass from downstream Lake Powell may migrate through this area, only Channel Catfish are established in the reach. These conditions, however, apparently impose stresses on individual Humpback Chub that limit their body size and reproductive potential. Nevertheless, this population is expected to continue to remain small and persistent for 16 years with appropriate and effective threats management.

Dinosaur National Monument—The population of DNM, which previously inhabited Yampa and Whirlpool Canyons, is currently below detection limits and is considered functionally extirpated. While the flow and temperature regimes in the Yampa River are largely unchanged from historical conditions (with the exception of reduced base flows during the irrigation season), nearby Whirlpool Canyon on the Green River is highly modified by the presence of Flaming Gorge Dam. Modified operations over the past decade, and a temperature control device on Flaming Gorge Dam provides more natural flows and warmer water for the Green River, and are expected to continue into the future. Flow management in Yampa Canyon is expected to be improved as well. In 2007, the Recovery Program secured a permanent source of summer augmentation water (5000 acre-feet with an option to lease an additional 2000 acre-feet) in Elkhead Reservoir in the upper Yampa River drainage. The Recovery Program has used the permanent pool every year since 2007 to improve summer base flow conditions in the lower Yampa River including Yampa Canyon. Flow augmentation could benefit future efforts to repatriate Humpback Chub in DNM.

Smallmouth Bass (primarily juvenile sized fish) can comprise as much as 10% of the Yampa Canyon fish community during and following years of high production upstream. However, the species has not colonized Yampa Canyon in high densities over the long term, like it has in adjacent reaches. Significant efforts are underway to control spawning congregations of Smallmouth Bass in the Yampa River and to eliminate escapement from upstream reservoirs. We expect under scenario 1, Smallmouth Bass density will never exceed 10%, and instances of this density will remain uncommon.

The number of Humpback Chub remaining in this population is probably too low to expect population recovery. Translocations of fish from other populations (as in the Grand Canyon) or stocking of hatchery-reared individuals could reestablish a functional population in this area if coupled by appropriate and effective management of flow (see above) and nonnative fishes.

Grand Canyon—The Grand Canyon population is the largest population of Humpback Chub, and is likely to continue to be self-sustained for 16 years with appropriate and effective threats management. The physical habitat is largely intact, and sediment will continue to be managed by flow. The future flow regime is described in the 2016 LTEMP EIS (U.S. Department of the Interior 2016), in which GCD releases are designed to benefit canyon resources. Future river temperature is somewhat uncertain. If drought continues and Lake Powell continues to drop in elevation, warm dam releases will continue during the months of August–October, with consequent potential effects including increased abundance and distribution of nonnative fish. The future of the food supply is also uncertain, and ongoing research is attempting to determine the causes for low food supply and strategies for enhancing instream production.

Predation/competition by Rainbow Trout and Brown Trout is likely to continue, and research is ongoing to better understand management strategy. An increase in numbers of Brown

Trout in Lees Ferry began in 2013, but stakeholders are collaborating on actions to control this and other potentially invasive species, such as Green Sunfish. Smallmouth Bass and Walleye may expand in numbers and distribution and lead to more predation on young Humpback Chub, if management actions are unable to avert an increase in these nonnative species. The threat of a spill at the Cameron Bridge seems to be reduced with reconstruction of U.S. Highway 89 and the bridge and interchange in that area. Catastrophic events may continue to affect tributaries, if conditions such as wild fires are followed by heavy rainstorms and ash-laden floods or debris flows. Impediment to movement between the upper and lower basins will persist with the presence of Glen Canyon Dam, and it may be necessary at some future time to mix fish across basins.

Movement of fish within the Colorado River in Grand Canyon is expected to continue unimpeded, and translocations of young fish into tributaries above falls and chutes should continue. The core LCR population is expected to continue to reproduce and recruit annually. Mainstem reproduction and recruitment is also expected with warmer dam releases, and range expansion into western Grand Canyon is expected with exposed historical habitat from the receding levels of Lake Mead. The expansion in western Grand Canyon could lead to a second population of Humpback Chub in the lower basin. Genetic diversity is expected to persist. Perhaps the least recognized future threat to the Grand Canyon population is continued pumping of water from the Coconino aquifer, which is the source of water for base flow of the LCR and Havasu Creek. A sudden and substantial decrease in flow in these tributaries—particularly the LCR—could be disastrous to the Humpback Chub population in Grand Canyon.

Table 18. A summary of the future condition of species needs under Scenario 3 for the six populations of the Humpback Chub. Color codes: dark green = resource condition is good; light green = fair; yellow = neutral; orange = poor; red = bad.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
1. Diverse rocky canyon river habitat	**Good** • Physical habitat of optimal condition. • Intact, protected and likely to persist.	**Good** • Physical habitat of optimal condition. • Intact, protected and likely to persist.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist.	**Fair** • Physical habitat intact but consists of mostly talus reaches. • Protected and likely to persist. • Some encroachment by nonnative vegetation armors cobble bars and limits spawning.	**Good** • Physical habitat largely intact, available sediment managed by flow.
2a. Suitable flow	**Fair** • Little additional flow alteration expected. • Episodes of drought will contribute to flow reduction, but the UCRRP has demonstrated a commitment to spring peak and base flow augmentation throughout the upper basin. • Reclamation's ROD at the Aspinall Unit serves and other long term flow commitments ensure important flow management in the future.	**Fair** • Little additional flow alteration expected. • Episodes of drought will contribute to flow reduction, but the UCRRP has demonstrated a commitment to spring peak and base flow augmentation throughout the upper basin. • Reclamation's ROD at the Aspinall Unit serves and other long term flow commitments ensure important flow management in the future.	**Fair** • Little additional flow alteration expected. • Episodes of drought will contributed to flow reduction but the UCRRP has demonstrated a commitment to spring peak and base flow augmentation throughout the upper basin. • Reclamation's ROD at Flaming Gorge Reservoir and the Elkhead Reservoir supplemental water, and other long-term flow commitments ensure important flow management in the future.	**Fair** • Little additional flow alteration expected. • Episodes of drought will contribute to flow reduction but the UCRRP has demonstrated a commitment to spring peak and base flow augmentation throughout the upper basin. • Reclamation's ROD at the Aspinall Unit and Flaming Gorge Reservoir ensure important flow management in the future.	**Neutral** • Flow regulation of Yampa and Green rivers not expected to change. • Flow reduction in Yampa likely to recur but the UCRRP has secured supplemental water at Elkhead Reservoir to augment summer base flows.	**Neutral** • Flow is determined by LTEMP EIS and GCD[a] releases designed to benefit canyon resources.
2b. Suitable temperature	**Fair** • Temperature is expected to warm, but effect on fish not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on fish not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on fish not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on fish not expected to be measureable.	**Fair** • Temperature is expected to warm, but effect on fish not expected to be measureable.	**Fair** • Drought-induced low level of Lake Powell likely to result in warmer water releases. • Cold releases from GCD possible but less likely as reservoir filling or Temperature Control Device not expected in this timeframe.
3. Adequate and reliable food supply	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Good** • Food supply is expected to persist.	**Fair/Enhanced Through Management** • Food supply may continue to be limited; studies are ongoing for better insect production.
4. Habitat with few nonnative predators and competitors	**Fair** • Some predation/competition likely to continue. • Colonization of problematic species is unlikely given past	**Fair** • Some predation/competition likely to continue. • Colonization of problematic species is unlikely given past	**Neutral** • Predation/competition likely to continue. • Monitoring and removal of the expanding Smallmouth Bass	**Fair** • Minor predation/competition likely to continue. • Conditions unlikely to support problematic nonnatives.	**Neutral** • Predation/competition likely to continue.	**Neutral** • Some predation/competition likely to continue but additional effective tools available to control.

Resource Category	Black Rocks	Westwater Canyon	Desolation/Gray canyons	Cataract Canyon	Dinosaur National Monument	Grand Canyon
Habitat with few nonnative predators and competitors (continued)	conditions and future management. • Efficacy of nonnative fish management is vital, especially in years of low flow.	conditions and future management. • Efficacy of nonnative fish management is vital especially, in years of low flow.	population is vital; other problematic species are rare or absent. • Efficacy of nonnative fish management is vital especially in years of low flow.		• Yampa and Whirlpool Canyons not conducive to nonnative fish colonization. • Efficacy of nonnative fish management in the upstream Yampa River and the adjacent Green River is vital, especially in years of low flow.	• Temperature regulation device possible but assumed highly unlikely in a 16-year timeframe. • Ability to regulate warming important to prevent warm water nonnative establishment.
5. Suitable water quality	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Emergency response plans and safety shutoff valves on pipelines will reduce threat.	**Neutral—Uncertain** • Effects of persistent contaminants on Humpback Chub not well understood. • Fish kills may continue in tributaries from ash-laden floods and debris flows after wild fires.
6. Unimpeded range and connectivity	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, and Redlands may expand upstream range.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, and Redlands may expand upstream range.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Tusher Wash may expand facilitate movement among populations.	**Good** • No impediment for movement to other populations in upper basin. • Fish passage at Price-Stubb, Grand Valley, Government Highline, Redlands, and Tusher Wash diversions may expand upstream range.	**Neutral** • No impediment for movement to other populations in upper basin, but population seems to distant from others to recolonize.	**Good** • Natural barriers in tributaries not expected to be modified for passage. • Translocations of young fish expected to continue.
7. Persistent population	**Good** • Population expected to continue to reproduce and recruit annually. • Management expected to continue to support populations. • Recent estimates indicate stabilization since 2007.	**Good** • Population expected to continue to reproduce and recruit annually. • Management expected to continue to support populations. • Recent estimates indicate stabilization since 2007.	**Fair** • Population expected to continue to reproduce and recruit annually. • Management expected to continue to support populations. • Evidence is insufficient to define population trajectory.	**Good** • Population expected to continue to reproduce and recruit annually. • Management expected to continue to support populations. • Population remained small but persistent since discovered in 1980.	**Neutral** • Translocation of fish from other populations may be successful in establishing a reproducing population. • Management expected to continue to support populations.	**Good** • Core Little Colorado River population expected to continue to reproduce and recruit annually. • Mainstem reproduction and recruitment expected with warmer water. • Range expansion expected with increasing numbers in mainstem and from tributary translocations.
8. High genetic diversity	**Good** • Genetic diversity expected to continue. • Exchange of fish with Westwater Canyon will continue to support genetic diversity.	**Good** • Genetic diversity expected to continue. • Exchange of fish with Black Rocks will continue to support genetic diversity.	**Fair** • Genetic diversity expected to continue. • Some loss of diversity may occur over long time period due to low exchange with other populations.	**Fair** • Genetic diversity expected to continue. • Some loss of diversity may occur over long time period due to low exchange with other populations.	**Neutral** • Translocation will support high genetic integrity in conjunction with population establishment. • Numbers of *Gila cypha* expected to remain low.	**Good** • Genetic diversity expected to continue. • Large reproducing populations in diverse habitats will continue to support genetic diversity.

[a] GCD = Glen Canyon Dam

6.0 SPECIES VIABILITY

6.1 Resiliency, Redundancy, and Representation

This assessment has so far described and evaluated species needs, current condition, and future condition of resources needed by the Humpback Chub. This section summarizes the importance of species-specific attributes in meeting the 3 R's (resiliency, redundancy, and representation) that together represent viability. Species-specific attributes are those inherent life history and genetic traits and characteristics that are important for coping with a variable and changing environment—in the present and into the future. These species attributes are the cornerstones of species viability, and are more fully described in sections 2.0 and 3.0. The species-specific attributes contribute to the conclusions developed for each of the three future scenarios presented in section 5 (see Tables 19 & 20 below).

6.1.1 Resiliency—Resiliency is the ability of individuals to withstand environmental or demographic stochasticity, as measured by species-specific traits and characteristics. The following are species-specific traits that enable individuals to be resilient in the face of environmental or demographic stochasticity:

1. ***Long life span:*** The Humpback Chub is a long-lived species, with some individuals living up to 40 years in the lower basin. This extended life span creates a storage effect with long-term survival of adults during adverse environmental conditions. The longevity allows individuals to persist through periods of drought and low flow, invasions of nonnative fishes, spills of toxic materials, and outbreaks of diseases and parasites, so that the few remaining individuals can rebuild the population during more suitable conditions.
2. ***High reproductive potential:*** The Humpback Chub lives for 20–40 years with the capability of spawning annually after the age of 4 or 5 years. Females produce ~2,500 eggs and spawn communally. This iteroparous reproductive strategy ensures that a large proportion of adults participate in spawning and that large numbers of eggs are produced. Evidence of skipped spawning has been seen in the Grand Canyon, which means that some adults may not spawn every year. This is evidently an energy conservation strategy to compensate for localized spawning movements, but it may also allow individuals to live longer and to build energy reserves for greater egg production.
3. ***Use of habitats arduous to other species:*** Humpback Chub are resilient to a variety of physical and chemical habitat conditions that are otherwise thought to be less suitable to other fish species. They inhabit deep canyon areas with swift flow. During spring runoff, flow in these canyons becomes turbulent with high velocity, and is laden with debris and turbidity. Many fish species are unable to cope with these conditions and are forced to leave. This defensive mechanism breaks down in low runoff years when conditions become less arduous and nonnative predators and competitors are able to invade these areas. Low runoff can also allow recolonization of native Roundtail Chub that compete and hybridize with Humpback Chub. In the LCR of the Grand Canyon, natural high total dissolved solids are unfavorable for

many fish species and serve to protect a principal spawning and nursery area of the Humpback Chub.

4. ***Wide flow range for life stages:*** The Humpback Chub appears to tolerate a wide range of river flows at all life stages. Upper basin populations have persisted through a wide range of historical and contemporary flows, and the population in Grand Canyon has experienced a dramatic change in the historical flow regime with the operation of Glen Canyon Dam. Yet, these populations appear to successfully complete their life cycles under these different flow regimes in different parts of the basin, albeit the Grand Canyon population relies very heavily, if not almost exclusively on the LCR for spawning and recruitment. However, a high and variable flow regime is needed to maintain channel diversity, stimulate food production, disadvantage nonnative predators and competitors, deliver episodic food supplies, and reduce abundance of competing and hybridizing Roundtail Chub. This hydrologic phenomenon occurs naturally in the upper basin, but is managed through dam operations and high-flow experiments in the Grand Canyon.
5. ***Wide temperature range for growth:*** The Humpback Chub is a warm-adapted fish that requires a narrow water temperature range of 16–22ºC for spawning and incubation. However, the species has a wide temperature range for growth of ~12–24ºC that allows individuals to inhabit areas with cool temperature. This adaptive trait is revealed with the contrast in water temperature in the Grand Canyon, where the species spawns primarily in the seasonally-warmed LCR, but resides in the cooler mainstem, where it has better health and greater longevity. The ability of the species to migrate annually to spawn in the warm LCR and retreat to the mainstem for possible post-spawn recovery and feeding appears to benefit the species and provide resiliency to individuals.
6. ***Variable and omnivorous diet:*** The Humpback Chub has a variable diet, such that individuals consume a large array of food items under different river conditions. This gives individuals a better chance of surviving catastrophes or periods of food shortage from a single source. Although the diet of larvae and age-0 Humpback Chub is fairly selective for diatoms and small invertebrates, older fish are less discriminating and capable of eating a large variety of foods. In the upper basin, the species has demonstrated an ability to consume invertebrates produced instream, as well as terrestrial and aerial insects, and animal and plant matter transported by large floods. In the Grand Canyon, a shift in diet from historical items to invertebrates produced in a post-dam era also demonstrates the resiliency of individuals to use available food items.
7. ***Use of turbidity for feeding and cover:*** The Humpback Chub is a high-turbidity adapted fish that is most active during episodic floods when the river is highly turbid and laden with a variety of animal and plant matter that is consumed as food. In the mainstem Colorado River in Grand Canyon, radio-tagged adults moved significantly greater distance and more often when turbidity was above 30 nephelometric turbidity units (NTUs); significantly greater movement at higher turbidity corresponded with higher gut content of food by adults (Valdez and Ryel 1995). Humpback Chub also appear to use turbidity as cover from potential predators. The vulnerability of juvenile Humpback Chub to predation by Rainbow Trout and Brown Trout was reduced with

increased turbidity in a laboratory setting (Paukert and Petersen 2007; Ward and Morton-Starner 2015), and higher turbidity corresponded with fewer feeding attempts by Rainbow Trout (as cited in Valdez and Ryel 1995). In Grand Canyon, turbidity may mediate piscivory by reducing prey detection, but Yard et al. (2011) found that Rainbow Trout piscivory was greater when suspended sediment levels were high (range = 5.9–20,000 mg/L). This may be attributed to a greater frequency of feeding forays by Humpback Chub during turbid conditions and thus, greater exposure to predation. Humpback Chub may have historically fed during turbid conditions—a time in which most food was delivered by floods—but the species may be naïve to avoiding nonnative predators.

6.1.2 Redundancy— Species redundancy is supported by multiple, resilient populations distributed across the range of the species. The following are species attributes that support redundancy of Humpback Chub at the population level.

1. ***Independent susceptibility to threats from basin-wide distribution***: The Humpback Chub is currently found as six populations over a range of ~1,353 km in five major rivers or segments of the Colorado River System (Green, Upper Colorado, Yampa, Lower Colorado, and Little Colorado rivers), each with independent susceptibility to threats. Only the Black Rocks and Westwater Canyon populations are in close proximity to share a common risk of threats. For the other populations, an area-specific threat (e.g., ash-laden flood, oil spill) cannot simultaneously affect multiple populations. The only threat that spans across the basin and affects these multiple populations is the potential effect of reduced water availability and specifically periods of drought, as seen during 1995–2002 (see section 4.5).
2. ***Large basin-wide number of individuals***: The total number of Humpback Chub in the Colorado River System is estimated at 16,000 adults, based on concurrent 2012 estimates. This includes ~3,800 adults in the upper basin and 12,250 adults in the lower basin (12,000 associated with the LCR and 250 in the mainstem). By comparison, at least one to two orders of magnitude greater numbers of sub-adults and juveniles and still greater numbers of larvae are produced, and their abundance may vary on an annual basis. Five of the six populations (except for DNM) reproduce on an annual basis, have persisted for decades since major system alterations (flows and invasive species), and support a cross-section of ages. A large number of adults and young in multiple and separate populations provides resiliency and redundancy.
3. ***Ability to sustain small populations in limited habitat:*** The Humpback Chub has an apparent ability to persist in relatively small areas. The smallest area occupied by a population is a 1.4-km reach of the upper Colorado River in Black Rocks. This population was first reported in 1975, and although the number of adults has varied by more than three-fold in 14 years, the population has demonstrated resiliency. Similar patterns of population oscillation have been seen with the Westwater Canyon and Desolation/Gray canyons populations over the same time period. Although population size is clearly a factor in resiliency and redundancy, the Humpback Chub is evidently able to persist with small numbers of individuals in limited habitat.

4. ***Apparent ability to recover from toxic spills:*** Altogether, large ash and debris-laden floods have negatively affected populations in Shinumo Creek, Desolation/Gray canyons, and Westwater Canyon, and petroleum spills have entered Desolation/Gray canyons and Yampa Canyon. The effects of these events on the Humpback Chub were not evaluated, but dead fish were observed and the populations have persisted.
5. ***Storage effect from long life span:*** Humpback Chub may live 20–40 years and adults of multiple ages provide a storage effect in years when there is little reproduction or recruitment. Individuals grow slowly after reaching maturity; therefore, lengths of fish of different ages overlap and age groups are indistinguishable after their fourth year of life. This large super-cohort of adults provides a buffer during years of poor environmental conditions when reproduction, survival, and recruitment are low. This age structure of adults not only provides a storage effect to ensure resiliency against catastrophic events, but also provides the population with a robust cross-section of sizes and ages that may be differentially resilient to internal and external population pressures and threats.
6. ***Demonstrated population recovery:*** The population of Humpback Chub in the Grand Canyon has shown a high level of resiliency with a decline in adults of ~54% over a 13-year period (1989–2001) followed by an increase of nearly 140% over a 12-year period (2001–2012) and an apparent stability to the present day. Estimates of abundance in upper basin populations are insufficient to detect this level of change, but numbers of adults have increased or decreased over time, illustrating that population sizes are variable and capable of responding to environmental conditions and management actions.
7. ***Ability to expand and translocate:*** The Humpback Chub has showed a high potential for redundancy through three successful translocations of individuals in the Grand Canyon: to the LCR above a series of falls; to Shinumo Creek; and to Havasu Creek. The fish in Shinumo Creek were killed or displaced by large ash and debris-laden floods, but the fish in Havasu Creek and in the LCR have reproduced. The species has also demonstrated an ability to naturally expand in distribution. Natural expansion has occurred in western Grand Canyon after Lake Mead receded and exposed the historical river channel once occupied by the species; Humpback Chub of various sizes and ages were found in 2014 and 2015 as a sign of expansion and possibly local reproduction. A similar expansion may be taking place in Cataract Canyon with receding levels of Lake Powell. Translocations of Humpback Chub to Grand Canyon tributaries have been successful and may be a viable strategy for population restoration or expansion in the upper basin.
8. ***Potential for additional reproducing populations:*** An important dimension of population redundancy in the Grand Canyon is the emerging evidence of successful reproduction in the mainstem and at least one additional tributary (Havasu Creek). Successful spawning outside of the LCR has a large effect on redundancy of the Humpback Chub in the lower basin. Continued reproductive success in one or more locations other than the LCR (e.g., mainstem in western Grand Canyon and Havasu Creek) minimizes the risk of losing a large part of the population to a catastrophic event and provides additional sources of naturally-produced fish.

6.1.3 Representation—Representation is the ability of a species to adapt to changing environmental conditions over time, as indicated by genetic and environmental diversity within and among populations. The following are attributes of Humpback Chub that support representation:

1. ***Ability to adjust to changing habitat condition:*** Physical habitat of the Humpback Chub in the upper basin has remained largely intact, except for changes in flow regime and invasions of nonnative plants that have had less effect on canyon areas than on alluvial reaches. Habitat in the Grand Canyon was altered by Glen Canyon Dam in 1963 and although flow, temperature, food supply, and sediment are altered, the geomorphic foundation is largely intact. The Humpback Chub in the Grand Canyon has shown a remarkable ability to adjust to these changing conditions and continues to be the largest population in existence.
2. ***Genetic diversity of populations maintained by small exchange of individuals:*** No natural exchange of individuals has occurred between upper and lower basin populations for over 50 years, since construction of Glen Canyon Dam in 1963. Limited exchange of individuals occurs among populations in the upper basin, and dispersal and mixing among fish in the LCR and the mainstem in Grand Canyon. Genetic analysis indicates a historically low level decadal exchange of individuals among populations that was sufficient to ensure genetic diversity. However, that level of exchange among upper basin populations is too low to provide demographic rescue, other than to possibly help maintain adult numbers in the smaller Black Rocks population as movement from the larger Westwater Canyon population.

   An important measure of genetic diversity is effective population size (N_e), which is a theoretical measure of the number of breeders in the population that contribute to genetic diversity. General guidelines for fish suggest that a population with N_e of 500 or greater has a low risk of losing genetically adaptive traits; whereas a population with 50 or fewer individuals is highly vulnerable to inbreeding depression and genetic drift (Allendorf et al. 1997; Reiman and Allendorf 2001). The computed N_e for the LCR population of 12,000 adults is 899–1,437 adults, which indicates that the N_e's for the current numbers of adults in Black Rocks (404), Westwater Canyon (1,315), Desolation/Gray canyons (1,672), and Cataract Canyon (295) are probably quite low. Nevertheless, these populations have persisted for over 20 years of monitoring, and maintained genetic diversity. The persistence of these small upper basin populations illustrates that the numbers of adults alone does not foretell population stability.
3. ***Use of different and diverse habitats:*** Humpback Chub in the Grand Canyon occupy habitats in the LCR and the mainstem Colorado River as part of their normal life cycle. These habitats are very different and diverse and demonstrate the adaptability of the fish to live in very different environments, even at a local scale. This trait also enables individuals to use a wide range of areas in the Grand Canyon as historical habitat becomes increasingly exposed with lowered levels of Lake Mead. Additionally, Humpback Chub have been successfully translocated into three tributaries (upper LCR, Havasu Creek, and Shinumo Creek) showing that they can live and reproduce in new environments.

6.2 Summary of Species Viability

Species viability is assessed within the context of the three future scenarios presented in section 5 over a biologically meaningful timeframe of two generation times or 16 years. For each scenario, an assessment of resiliency, redundancy and representation is presented based on each scenario's expected biological outcome. Both the species needs and the species-specific attributes listed above were considered in the assessment. For each scenario, we outline the possible biological outcome and elucidate the effects on resiliency, redundancy and representation (Table 20).

Scenario 1 [Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated] - includes an elimination of some active and adaptive actions, and a reduction in voluntary management actions for the species, such that many stakeholder actions are no longer in place to mitigate future conditions including decreased water availability, future water development, or nonnative fish. Without management action, we expect that the Dinosaur National Monument population will remain functionally extirpated with little hope of recovery. The population in Desolation/Gray canyons is likely to decline rapidly primarily because of an overwhelming influence of nonnative fish invasion. Individual Humpback Chub would be expected to remain in pockets throughout the canyon, but would not function as the current population does. It is possible that known nonnative predators, such as Walleye and Smallmouth Bass, would develop larger populations directly influencing Black Rocks and Westwater, likely threatening the resiliency of those populations. One or more additional population (in addition to DNM) would be expected to decline to functional extirpation. The Cataract and Grand Canyon populations would maintain higher resilience because the risk of invasion of nonnative predators in those areas is lower than other places in the upper Colorado River basin. Although the UCRRP is only authorized through 2023, stakeholders have indicated continued support for management of the endangered species in the Colorado River. Recent commitments (LTEMP) in the lower basin virtually guarantee future management of the Grand Canyon ecosystem.

Scenario 2 [Legally Mandated Management Actions and Additional Adaptive Management Actions Occur, but are Ineffective] - in addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies' management practices occur into the future for the species, but these actions are ineffective to mitigate impacts of drought, future water development, nonnative fishes, or other threats. Management action would encourage the repatriation of Dinosaur National Monument, though the resiliency of that population would remain under threat from nonnative predators, especially if management actions are insufficient to reduce nonnative populations. The Humpback Chub populations in Desolation/Gray canyons, Westwater and Black Rocks would likely receive additional pressure from nonnative predators/competitors and populations would continue to decline. Declines would be unlikely to remove populations within the 16-year time frame, but may over a longer time frame. Cataract Canyon and the Grand

Canyon populations would likely continue to fluctuate and represent the most resilient populations in the long term.

Scenario 3 [Legally Mandated Management Actions and Adaptive Management Actions Occur, and Are Effective] - in addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies' management practices occur into the future for the species, and these actions are sufficient to mitigate impacts of drought, future water development, nonnative fishes, or other threats. Management actions would be moderately likely to repatriate Dinosaur National Monument with continued management actions. The populations in Desolation/Gray canyons, Black Rocks and Westwater would fluctuate based on environmental carrying capacity, and would be likely to continue stabilization or increasing trends. Cataract and Grand Canyon populations would likely fluctuate over time.

It is apparent that the species is expected to be fairly well represented and resilient in the future under scenarios 2 and 3. Redundancy is less certain, but primarily because of the potential to see declines in upper basin populations under ineffective management actions. If management actions can prevent a loss of an additional upper basin population, or re-establish the Dinosaur National Monument population (Scenario 3), conditions will be sufficient for the species.

Using these conclusions to consider species viability, species experts and the Service agree that based on the best available information, species viability is more tenuous in the upper basin than in the lower basin. One of the largest threats to the Humpback Chub, that of nonnative fish invasions, increases dramatically with time as invasions are difficult to predict – both in timing and extent of damage. In both scenarios 1 and 2, the potential effects of nonnative predation or competition indicate that the species may suffer declines within the foreseeable future. Scenario 3 is defined by conservation programs' ability to react to and reduce the threat from these invasions, and thus shows species viability continuing on its current trend or possibly increasing over time.

Ongoing and future management could be sufficient to offset threats and promote survival and recruitment for 30 years, but uncertainty exists regarding future management activities. Although many conservation efforts in the Lower Basin are guaranteed for more than 50 years in the future, efforts in the Upper Basin have not been contracted beyond 2023 or funded beyond 2019. Uncertainty remains surrounding current population trajectories of Humpback Chub, densities of nonnative predators in the upper basin, and risk associated with future conditions throughout the basin.

Table 19. Predicted conditions for resiliency, redundancy, and representation in the upper basin relative to a biologically meaningful timeframe (2-generations; 16 years) under three possible future scenarios. Color codes: dark green = good; light green = fair; yellow = neutral; orange = poor; red = bad.

		Resiliency	Redundancy	Representation
Upper Basin	S1 – **Extralegal Adaptive Management Ceases**	**Bad** • Flow regimes no longer provide the inter- and intra-annual variability to support healthy Humpback Chub populations and preserve the historical balance with Roundtail Chub; Reclamation's Records of Decision at Flaming Gorge and Aspinall provide legal safeguard that would prevent catastrophic low flow. • Conditions become conducive to establishment of Smallmouth Bass and possibly other nonnative species. Nonnative predator densities increase throughout the upper basin and likely establish in Humpback Chub population centers. • Humpback Chub densities in all upper basin populations expected to decline quickly.	**Bad** • A DNM repatriation effort does not occur or is not successful. • One or more upper basin population is extirpated (most likely Deso/Gray; possibly Black Rocks) and the chances of repatriation are very low. • All other upper basin populations decline to levels that require intervention.	**Bad** • Genetic diversity and species adaptability throughout the upper basin could be irrevocably lost as populations are reduced below critical levels.
	S2 – **Extralegal Adaptive Management Continues, but prove Ineffective**	**Neutral** • Flow management is not adequate to support persistent Humpback Chub populations and percent composition of Roundtail Chub increases in all upper basin populations. • Smallmouth Bass and possibly unknown nonnative species exert greater predation and competition pressure (most likely in Desolation/Gray) despite fully implemented nonnative fish management strategy. • Humpback Chub densities in all upper basin populations are expected to decline gradually.	**Poor** • A DNM repatriation has a low probability of success. • Another upper basin population (most likely Desolation/Gray; possibly Black Rocks) declines to a level that requires intervention.	**Neutral** • Genetic diversity is compromised via population declines. • Site specific genetic management actions would be implemented and expected to succeed.
	S3 – **Extralegal Adaptive Management Continues and is Sufficient**	**Fair** • Flow management provides the inter- and intra-annual variability to support persistent Humpback Chub populations and preserve the historical balance with Roundtail Chub. Flow management preserves conditions that have precluded or limited establishment of Smallmouth Bass. • Nonnative fish management maintains conditions that limit establishment of known and unknown nonnative predators in Humpback Chub population centers. • Humpback Chub densities in all upper basin populations are expected to fluctuate around long-term, observed levels; and are expected to show periods of positive response in the near term (1 generation) in Black Rocks and Westwater Canyon.	**Fair** • A DNM repatriation has a moderate probability of success. • All four extant upper basin populations are expected to persist, maintaining redundancy.	**Fair** • Exchange of individuals between populations expected to continue. • Genetic diversity is preserved at current levels. • Hybridization with other *Gila* species expected to continue.

Table 20. Predicted conditions for resiliency, redundancy, and representation in the lower basin relative to a biologically meaningful timeframe (2-generations; 16 years) under three possible future scenarios. Color codes: dark green = good; light green = fair; yellow = neutral; orange = poor; red = bad.

		Resiliency	Redundancy	Representation
Lower Basin	S1 – **Extralegal Adaptive Management Ceases**	**Poor** • Management actions outside LTEMP to address additional habitat and nonnative stressors (including foodbase, parasites, pollutants etc.) unavailable. • Lowered Lake Powell elevations, further main channel warming and greater risk of establishment of nonnative predators. • Lack of rapid response outside the LCR aggregation could allow for establishment of nonnative predators. • Increases in nonnative predators could result in a significant decline in abundance.	**Neutral** • Increased populations of nonnative predators could affect Humpback Chub populations in the main channel outside the LCR aggregation; less of an effect in smaller tributaries.	**Fair** • Nonnative predators could diminish genetic exchange, population size and reduce genetic diversity.
	S2 – **Extralegal Adaptive Management Continues, but is Ineffective**	**Fair** • Management actions not fully effective at preventing risk from lowered Lake Powell elevations and further main channel warming, partially effective at responding to establishment of new or expansion of existing nonnative predators/competitors. • Populations likely plateau or contract.	**Fair** • Humpback Chub expansion and distribution reduced, but redundancy resulting from translocations remains	**Fair** • Genetic exchange throughout the lower basin populations is expected to continue, with or without effective management.
	S3 – **Extralegal Adaptive Management Continues and Effective**	**Good** • Strong commitment to effective prevention and response actions to address risks from lower Lake Powell elevations (warmer water and nonnative predators/competitors), and other stressors (food base, parasites, pollutants, etc.). • Greatest likelihood of population response - largest congregation of adults and largest storage effect.	**Good** • Humpback Chub geographic expansion continues (West Grand Canyon and additional translocations) providing increased redundancy.	**Good** • Genetic exchange throughout the LB populations expected to continue; current level of genetic diversity is high. Very low risk that genetic diversity would be compromised in this timeframe.

The Humpback Chub is a long-lived species that has persisted for more than three million years during periods of extreme environmental stochasticity. Five of the six populations have persisted for decades during modification of resource conditions, including four in the upper basin and one in the lower basin. Only the population in DNM is considered functionally extirpated; intervention will be necessary to restore this population, including stocking or translocation of fish along with ongoing flow and nonnative fish management. The population in Grand Canyon is the largest with fish distributed in two tributaries and in the Colorado River from 72 km downstream of Glen Canyon Dam to the Lake Mead inflow; increased numbers of different sizes indicate successful reproduction in the mainstem and a downstream expansion of the population. Of the four upper basin populations, adults in Black Rocks, Westwater Canyon, and Desolation/Gray canyons have declined in the last decade, but may have now stabilized. The Cataract Canyon population is small and persistent.

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APPENDIX A: Measures, Acronyms, and Abbreviations

The metric system is used for all units of measure in this document, except for cubic feet per second and river miles. Cubic feet per second (cfs) is the standard unit of measure used by the U.S. Geological Survey for surface-water data (http://waterdata.usgs.gov/usa/nwis/sw). River mile (RM) is a location on a given river, as measured upstream or downstream along the center of the river channel from a predetermined point (e.g., river confluence or compact point). The standard of river miles used in this document is from published Belknap's river guides available to the public for the Colorado River Basin, including: Canyonlands River Guide, Desolation River Guide, Dinosaur River Guide, and Grand Canyon River Guide.

The following is a list of acronyms and abbreviations used in this document:

ac-ft	acre feet
AGFD	Arizona Game and Fish Department
ASMRASMR	Age-Structured Mark-Recapture model
AZ	Arizona
BLM	Bureau of Land Management
C/m^2	Carbon per square meter
CFR	Code of Federal Regulations
cfs	cubic feet per second
CI	Confidence Interval
CNP	Canyonlands National Park
CPUE	Catch per unit effort
CROS	Coordinated Reservoir Operations
DNA	Deoxyribonucleic acid
DNM	Dinosaur National Monument
E	Ephemeroptera
EA	Environmental Assessment
ESA	Endangered Species Act of 1973
FEIS	Final Environmental Impact Statement
FONSI	Finding of No Significant Impact
FR	Federal Register
g/m^2	gram/meter squared
GCD	Glen Canyon Dam
GCDAMP	Glen Canyon Dam Adaptive Management Program
GCNP	Grand Canyon National Park
GCNRA	Glen Canyon National Recreation Area
GT	Generation time
HAZMAT	Hazardous Materials
IBM	Individual-based model

ISMP	Interagency Standardized Monitoring Program
KAF	thousand acre-feet
kg	kilograms
km	kilometer
LCR	Little Colorado River
LTEMP	Long-Term Experimental and Management Plan EIS
MAF	million acre-feet
mg/L	milligrams/Liter
mm	millimeters
msat	microsatellite genetic analysis
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
mtDNA	mitochondrial DNA
MVP	Minimum Viable Population
NASRF	J.W. Mumma Native Aquatic Species Restoration Facility
N_b	number of breeders in a population
N_c	census size
N_e	genetic effective population size
NP	Northern Pike
NPS	National Park Service
NS	Not sampled
NR	Not reported
P	Plecoptera
PBO	Programmatic Biological Opinion
P.L.	Public Law
PVA	Population Viability Analysis
Reclamation	Bureau of Reclamation
RK	River Kilometer
RM	River Mile
S	Survival rate
Service	U.S. Fish and Wildlife Service
SMB	Smallmouth Bass
SNARRC	Southwestern Native Aquatic Resources and Recovery Center
Spp	Species
SR	State Road
SSA	Species Status Assessment
STReaMS	Species Tagging Research and Monitoring System
T	Tricoptera
TL	Total length

UCRRP	Upper Colorado River Endangered Fish Recovery Program
UDWR	Utah Division of Wildlife Resources
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
TDS	Total Dissolved Solids
WE	Walleye
WS	White Sucker
°C	degrees Celsius
°F	degrees Fahrenheit

APPENDIX B: Stream Flow and Temperature Predictions

B.1 Basin-Wide Projections—The future condition of the Humpback Chub is driven largely by environmental factors linked primarily to flow and temperature. Flow and temperature of the Colorado River System have been influenced for the last century by human activities that have regulated hydrology basin-wide and altered river temperature in short reaches below impoundments. This reduced flow and altered temperature have been exacerbated in the last 5–6 decades by periods of drought. These periods are marked by reduced stream flow and increased air temperature and evaporation that are likely to continue and result in a number of ecological consequences, including, but not limited to reduced habitat availability, increased abundance and expansion of nonnative predaceous and competitive fish species, altered food supplies, and shifts in reproductive timing.

To examine future environmental condition for the Humpback Chub, it is important to set the stage with a characterization of historical and recent hydrology for the Colorado River System. Seven reconstructions of the Colorado River annual flow at Lees Ferry (Colorado Water Conservation Board 2012), based on calibration of tree-ring data, show that over a 500-year period (1492 to 1992), flow has varied by over 200% in approximately 20 to 60-year cycles (Figure 25). These reconstructions show that most recently, the Colorado River has been in a high-flow cycle until the mid-1980s, at which time a regional drought began that has lasted for over 30 years. The reconstructions illustrate the wide range of historical low and high water volumes (~8–19 MAF), as well as the uncertainty behind the future hydrology of the Colorado River. Recent possible manifestations of reduced water availability add to the uncertainty of river flow and associated environmental conditions that affect the Humpback Chub.

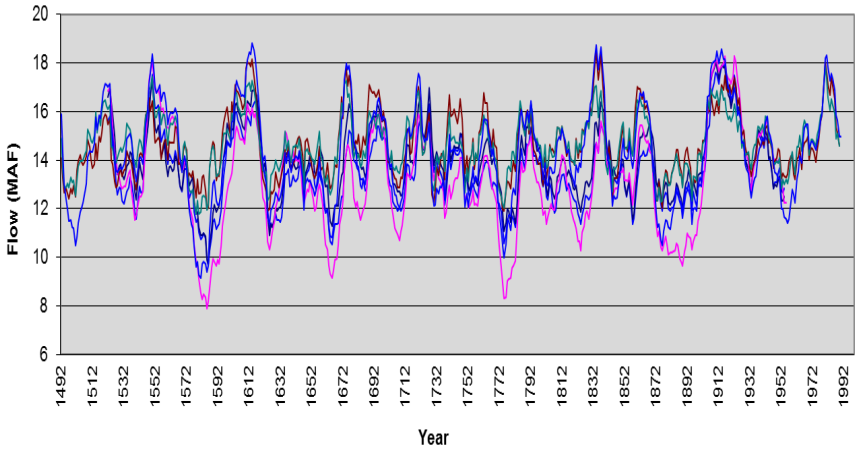


Figure 1. Seven reconstructions of Colorado River annual flow (as million acre-feet, MAF) at Lees Ferry, using tree-ring data. Source: Colorado Water Conservation Board (2012).

Recent and ongoing drought throughout the Colorado River System has resulted in increased air temperature and evaporation, despite a relatively stable annual precipitation (Figure 26; Christensen et al. 2004). Average air temperature in the U.S. has increased by 1.3°F to 1.9°F

since record keeping began in 1895; most of this increase has occurred since ~1970 (Melillo et al., 2014). The Western U.S. has warmed roughly 2°F and is projected to warm further during the 21st century (Reclamation 2016). Based on data available from the Western Climate Mapping Initiative, the change in 11-year annual mean air temperature during the 20th century is roughly +1.2°C (2.16 °F) for the upper basin and +1.7 °C (+3.06 °F) for the lower basin. Projected annual evaporation increases are typically around 2 to 6 inches by 2080 at most western reservoirs, including Lake Powell and Lake Mead.

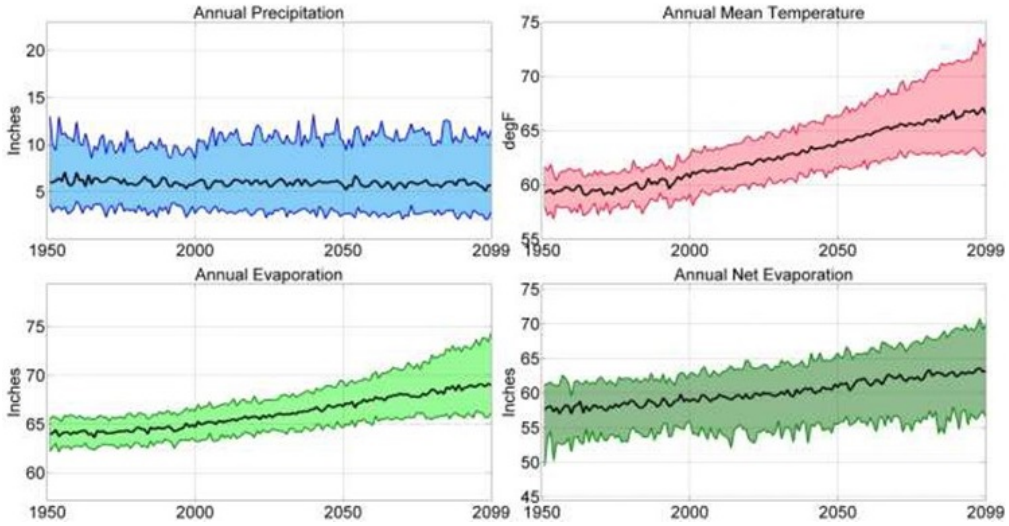


Figure 2. Projections for the Colorado River System (Lake Powell) of annual precipitation, temperature, reservoir evaporation, and net evaporation. The heavy black line is the annual time series of 50 percentile values. The shaded area is the annual time series of 5th to 95th percentiles. Source: Reclamation (2016), Figure 2-8.

A time-series plot of annual flow volume for Lees Ferry (1890–2004) and Lake Powell inflows reveals a decadal decrease of ~7.5% (Figure 27). This downward trend in stream flow volume of the Colorado River is not explained solely by increased air temperature and evaporation. It is also linked to the sensitivity of the snowpack accumulation process that dominates the spring runoff, and to a high and increasing water demand relative to supply (Rasmussen et al. 2014). One notable trend in hydrology is reduced winter snowpack with a shift in precipitation from winter to early spring. This shift has resulted in late winter and early spring precipitation occurring primarily as a snow/rain mix with immediate runoff and less snowpack accumulation. Highest precipitation levels now occur in spring with peak stream flow having shifted from June to May and lower stream flow in summer and fall.

In summary, projected basin-wide precipitation is not expected to change appreciably over the next 75 years, but because of increasing air temperature and evaporation, stream flow is expected to decrease.

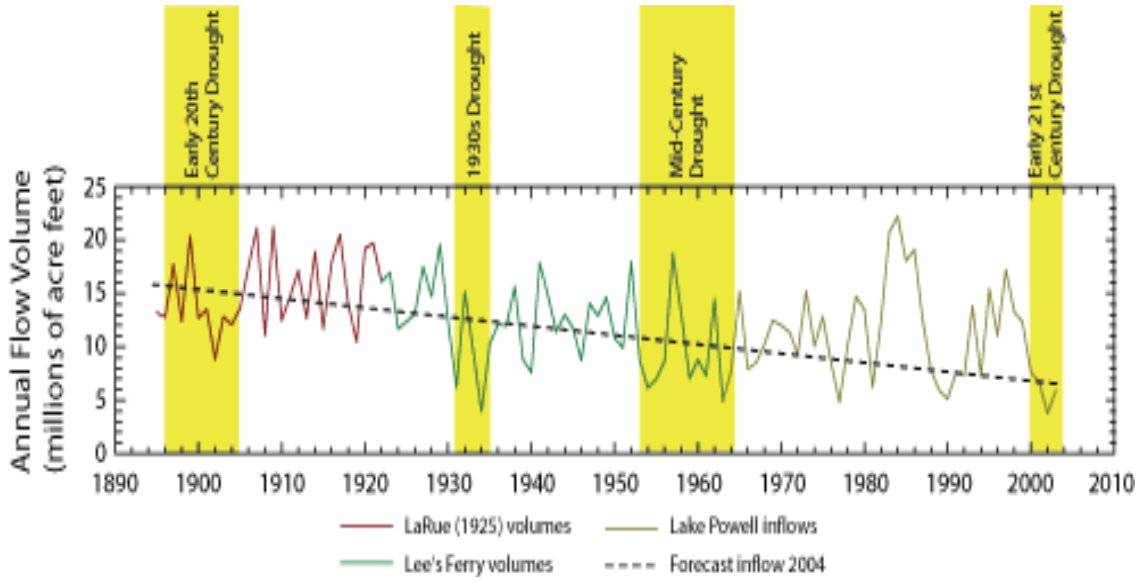


Figure 3. Time-series plot of the annual flow volume (in millions of acre-feet) at Lees Ferry and Lake Powell inflows. Dashed line is the linear trend for the period. Vertical bars and shading delineate drought periods as defined by the Palmer Drought Severity Index for the climate divisions encompassing the upper Colorado River basin. Source: http://pubs.usgs.gov/fs/2004/3062/.

B.2 Upper Basin—The populations of Humpback Chub in the upper basin have each changed trajectory in adult abundance during the period of monitoring (see section 6.1). These changes in intrinsic growth are driven largely by reproductive success, survival, and recruitment that are linked to a complexity of environmental factors. These linkages are not well understood, but apparent correlations suggest possible causation related primarily to stream flow. Additional monitoring and research are needed to better understand these relationships and causations.

Relationship of Stream Flow to Adult Humpback Chub Abundance—An examination of the hydrograph of the Colorado River at Stateline shows that flow magnitude, represented as maximum daily flow by year, declined steadily from ~50,000 cfs in 1995 to ~5,000 cfs in 2002, or a 90% decrease over a 7-year period; maximum daily flow in 2002 was the lowest in 26 years (Figure 28A). After 2002, maximum daily flow remained stable, except for the low of 2012. Overall trend in flow for 17 years (1995–2015) was a slight but insignificant decline ($p = 0.3671$), while declines in adult Humpback Chub in Black Rocks and Westwater Canyon were significant ($p = 0.0014$ and 0.0015, respectively).

A similar analysis was done for the Green River and adult abundance in Desolation/Gray canyons (Figure 28B). Maximum daily flow in the Green River decreased from ~30,000 cfs in 1995 to ~9,000 cfs in 2002, or ~70% decline. Although flow decline in the Green River occurred about the same time as on the Colorado River (1995–2002), abundance estimates of

Humpback Chub were not available for that time, but an apparent decline in adults occurred during 2006–2015, though not significant (p = 0.2537).

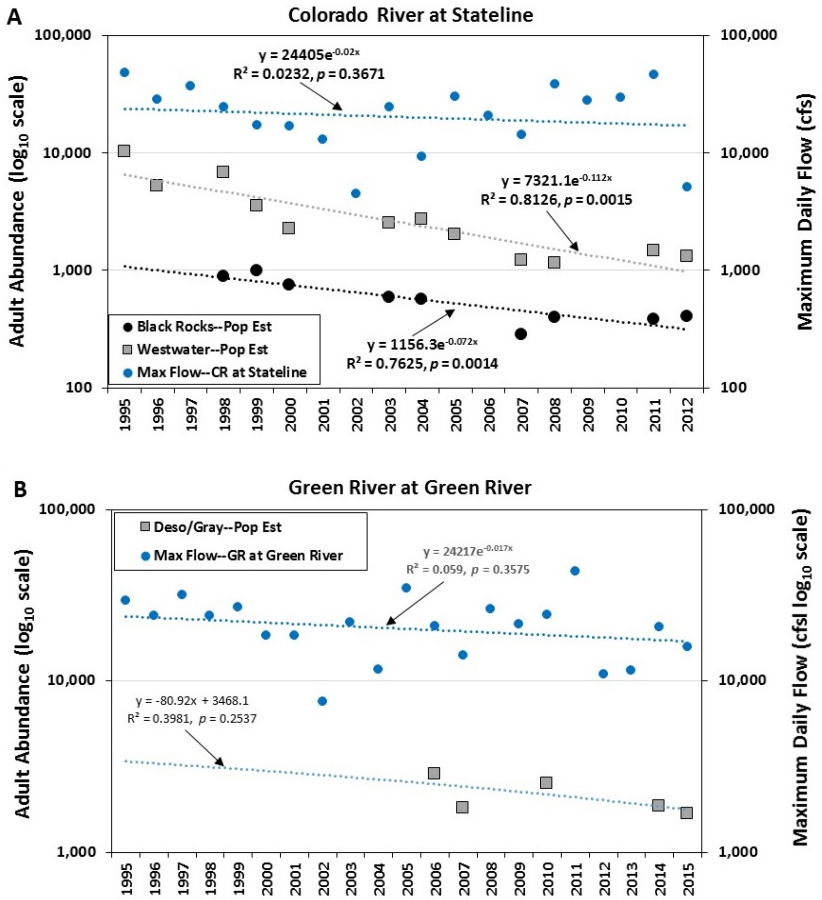


Figure 4. (A) Abundance of adult Humpback Chub in Black Rocks and Westwater Canyon, and maximum daily flow by year of the Colorado River at Stateline, CO (USGS 09163500) for 1995–2012; and (B) abundances of adult Humpback Chub in Desolation/Gray canyons, and maximum daily flow of the Green River at Green, UT (USGS 09315000) for 1995–2015. A closer examination of these data illustrates how the decline in adult abundance was correlated to a decline in maximum flow for 1995–2002 in Black Rocks and Westwater Canyon (Figure 29). We hypothesize that the 7-year period of flow decline set the stage for the continued decline of these populations through reduced reproductive success, habitat, and food supply, as well as invasions of predaceous and competing fishes. The effect on adult abundance of Humpback Chub was seen 3 years after the low flow occurred, or about the time that fish recruit to the adult portion of the population.

According to Francis et al. (2016), the decline in Black Rocks adults from 1998 to 2007 was the result of relatively low adult survival and insufficient recruitment to replace adult mortality. Low adult survival was attributed to low river flow from drought and consequent ecological effects; whereas low recruitment was attributed to poor reproductive success and to predation of young fish by nonnative fish. A nearly identical pattern of peak flow and fish

abundance was seen in Westwater Canyon for 1995–2002, and a similar conclusion was reached by Hines et al. (2016) for the decline in adult abundance in that population. These analyses indicate that consecutive years of low spring flow are responsible for periodic declines in abundance of Humpback Chub in upper basin populations.

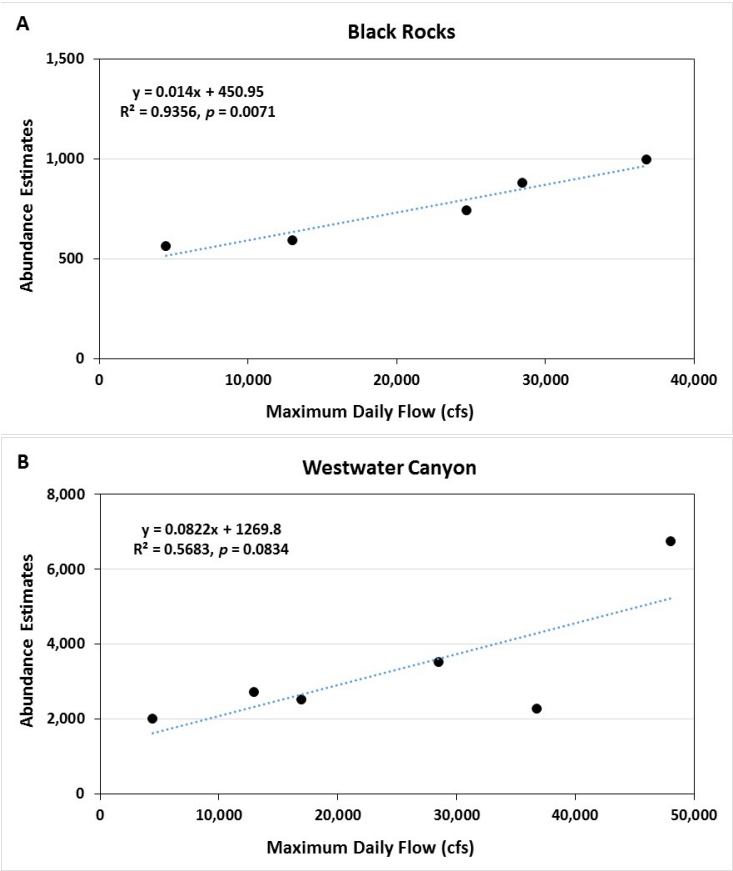


Figure 5. Adult abundance of Humpback Chub in (A) Black Rocks and (B) Westwater Canyon, correlated to maximum daily flow by year for the Colorado River at Stateline, CO (USGS 09163500) for 1995–2002. Adult abundance is correlated to river flow 3 years prior.

Relationship of Stream Flow to Adult Roundtail Chub Abundance—The low survival of adult Humpback Chub during periods of low spring flow may also be linked to higher numbers of Roundtail Chub that compete for food, space, and spawning habitat (that may result in hybridization). Inverse relationships were seen in Black Rocks and Westwater Canyon between adult Humpback Chub abundance and adult Roundtail Chub catch per unit effort (CPUE; Figure 30). In the period when maximum daily flow declined during 1995–2002, the density of Roundtail Chub increased as the number of adult Humpback Chub decreased in both populations. The mechanism behind this reduction is unclear, but is evidently linked to carrying capacity and competition with Roundtail Chub—as well as invasive nonnative fishes. This analysis indicates that annual change in flow magnitude may not have much effect on Humpback Chub populations, as long as periodic high flows occur. However, as observed for 1995–2002, a persistent period of low flow apparently has a

detrimental effect on populations by resulting in consecutive years of reduced adult survival and poor reproductive success with subsequent poor recruitment.

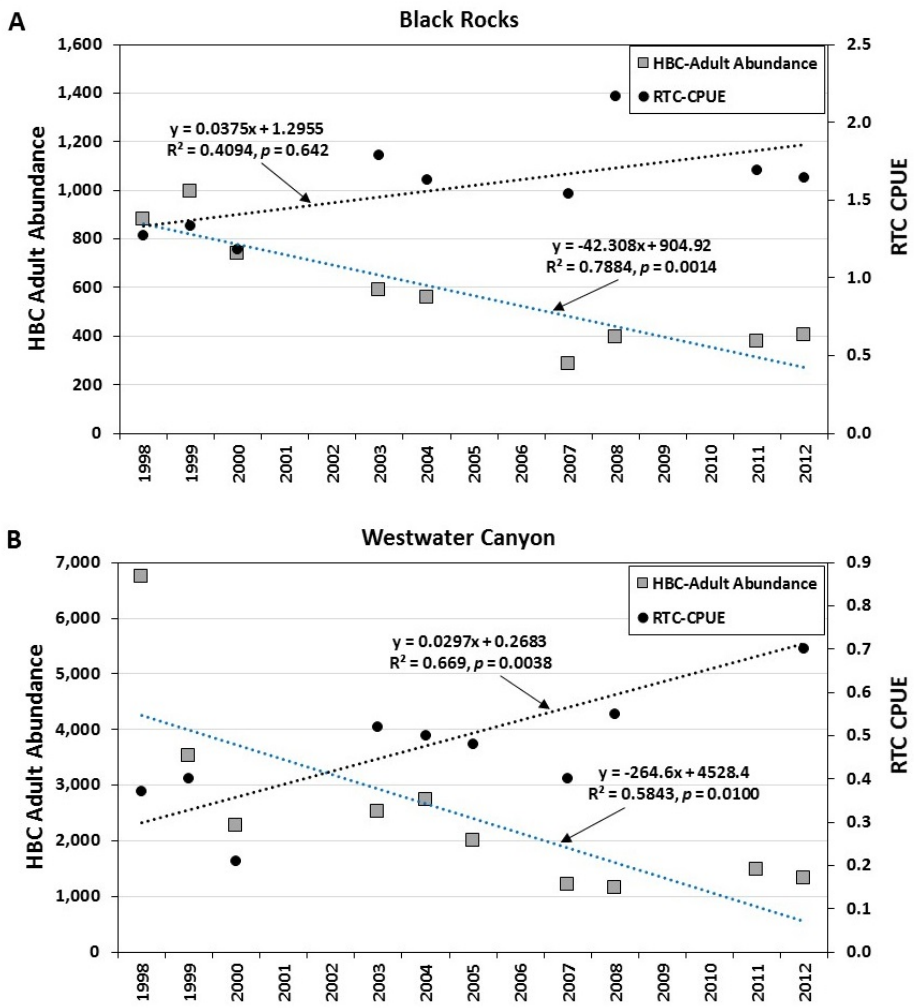


Figure 6. Adult abundance of Humpback Chub (HBC) and CPUE of Roundtail Chub (RTC) in (A) Black Rocks and (B) Westwater Canyon for 1995–2012.

Relationship between Stream Flow and Nonnative Fish--The abundance of nonnative fish differs with population in the upper basin (see section 4.1.4). Annual catch rate data from the Interagency Standardized Monitoring Program show the lower densities of nonnative fish and higher densities of Roundtail Chub in Black Rocks and the opposite condition in Desolation/Gray canyons (Figure 31). We hypothesize that invasion of these species is largely related to episodes of good Smallmouth Bass production in upstream areas during low spring peak flow. Influxes of juvenile Smallmouth Bass have been detected in Desolation and in the DNM population centers during low flow years, but densities typically drop off during wetter hydrologies. Smallmouth Bass have never been detected in appreciable numbers in Black Rocks, Westwater, and Cataract canyons, although they do exist in higher densities nearby in Ruby-Horsethief Canyon, the Grand Valley, and Lake

Powell. These relationships foretell a future effect of drought on the upper basin Humpback Chub populations, and on the future effect of nonnative fish and Roundtail Chub. It should be noted that past and recent genetic analyses indicate that hybridization and introgression are part of the evolutionary history of the Humpback Chub and are not expected to have a long-term effect on genetic diversity. However, a large number of Roundtail Chub in these confined population centers could impose sufficient competition to negatively affect Humpback Chub survival and subsequent recruitment.

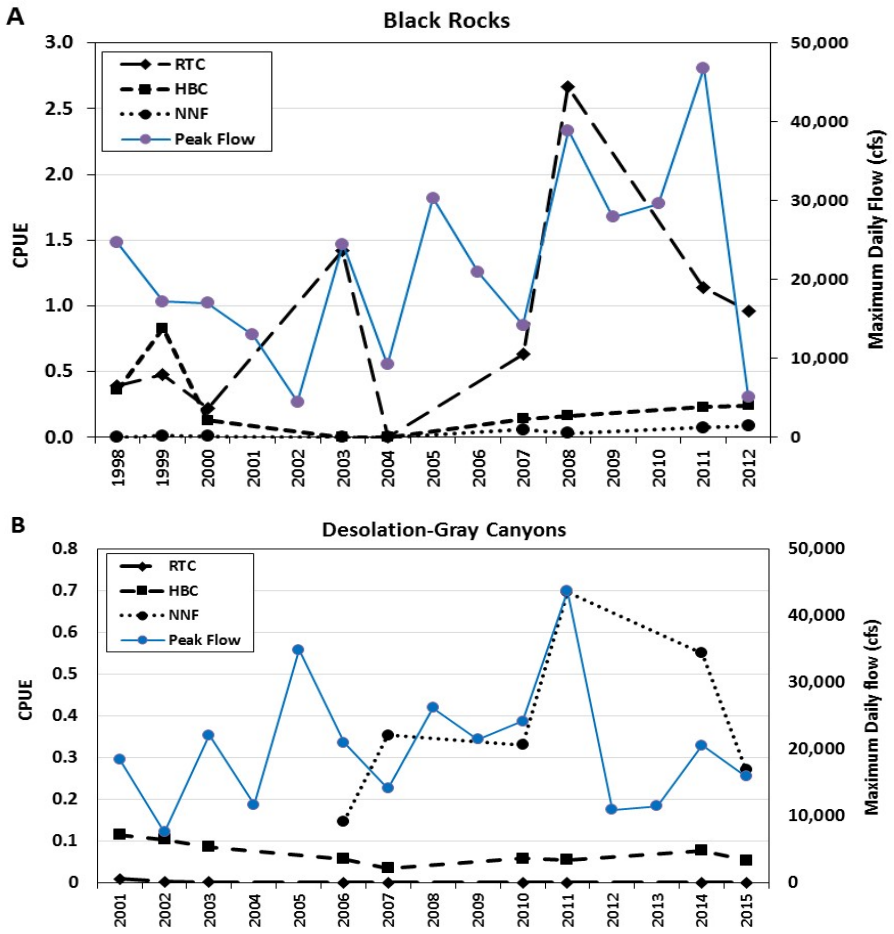


Figure 7. CPUE of Roundtail Chub (RTC), Humpback Chub (HBC), and nonnative fish (NNF) in (A) Black Rocks, 1998–2012, and (B) Desolation/Gray canyons, 2001–2015, compared to 3 years prior maximum daily flow for the Colorado River at Stateline, CO (USGS 09163500), and Green River at Green River, UT (USGS #09315000), respectively.

The most striking example of nonnative fish response to low stream flow was seen in the Yampa River during 1997–2002, when annual maximum daily flow dropped from 16,400 cfs to 3,420 cfs (Figure 32). Unfortunately this drought was coincident with a large release of Smallmouth Bass from Elkhead Reservoir (located in the Upper Yampa River drainage) when the reservoir was drained for dam repairs. The lowest daily flow of the Yampa River in 100 years of record occurred in August of 2002 at 1.8 cfs near Maybell; a flow of 2 cfs had been recorded in 1934. Density of Smallmouth Bass increased as the flow declined and conditions became suitable for spawning and survival of young. The population continued to increase to 2005 and declined thereafter as the result of an intensive bass removal program and a return to a wetter hydrology. Although flow in the Yampa River has resumed pre-drought level, Smallmouth Bass have persisted in the middle reaches of the Yampa River and mechanical removal continues as a strategy to manage the numbers of this invasive species (see section 5.4). This demonstrates how a nonnative fish species can take hold and how difficult it can be to reduce its numbers even after environmental conditions are more suitable for native fish species.

The decline of the Humpback Chub population in DNM apparently started with completion of Flaming Gorge Dam on the Green River in 1962, the associated rotenone treatment, and the effect of cold dam releases through Lodore and Whirlpool canyons. Forty years later Smallmouth Bass joined the existing suite of nonnative species and increased in number and distribution through the Green River subbasin. Main production zones for Smallmouth Bass in the Yampa River are immediately upstream of Yampa Canyon. Yampa Canyon experiences influxes of young Smallmouth Bass from those upstream spawning areas during years of good production (typically low water years). Those influxes undoubtedly have some impact on the native fish community of Yampa Canyon including Humpback Chub, but the native fish community has remained robust, with native sucker comprising the bulk of the fish community within the canyon.

This is the same mechanism that is believed to have taken place in Black Rocks and Westwater Canyon during 1995–2002, when extremely low flows for 4–7 consecutive years negatively impacted the Humpback Chub population. Fortunately, Smallmouth Bass are rarely encountered in these canyon reaches, despite occurring nearby in other portions of Ruby-Horsethief Canyon.

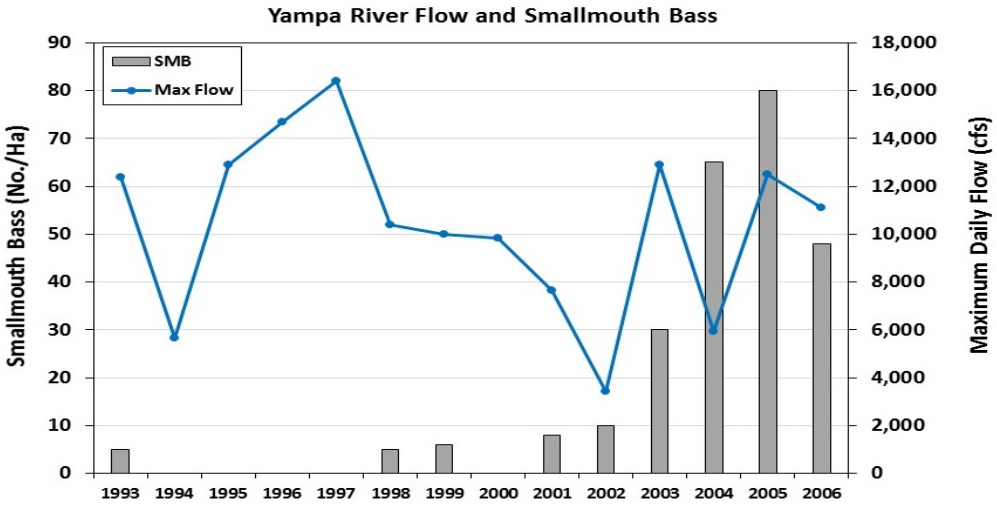


Figure 8. Decline in maximum daily flow of the Yampa River near Maybell, CO (USGS 09251000) for 1997–2002 and the corresponding increase in juvenile Smallmouth Bass (SMB) produced upstream. Density of Smallmouth Bass from Haines and Modde (2002). Large scale removal of Smallmouth Bass in the upstream Yampa River was initiated in the late 2000s.

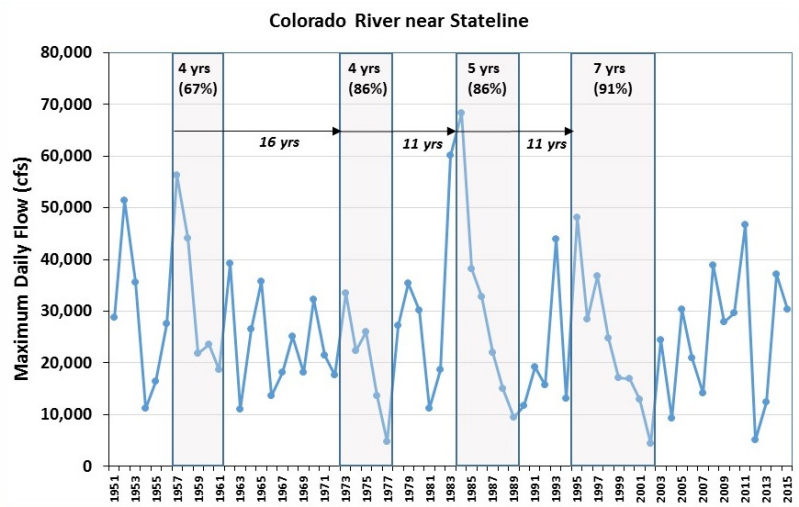
Frequency of Drought Episodes—Estimates of Humpback Chub adult abundance are available for upper basin populations only after 1995, and it is possible to link population decline with only one drought episode, 1995–2002. This episode affected the flow of all upper basin streams with a simultaneous decline in flow magnitude in the Upper Colorado, Green, and Yampa rivers. If the linkage described above between flow magnitude and Humpback Chub abundance is correct, one prediction is that downward population trajectory will be linked to episodes of drought 4–7 years in duration, and that stable or upward trajectory will be linked to wetter periods.

Four such episodes of drought (4–7 years duration) have occurred in the upper basin in the last 64 years, spaced 11–16 years apart (Figure 33). These episodes correspond to periods of low flow following peak flows of 1957, 1973, 1984, and 1995 (see Figure 27). Evidently, the upper basin populations have persisted through prior episodes of drought, but the presence of nonnative fish, especially the more recent predaceous forms like Smallmouth Bass and Walleye, have evidently exacerbated these conditions. If nonnative fish are capable of increasing in abundance within population centers, it becomes a foregone conclusion that predation and competition will suppress Humpback Chub populations during these drought episodes, and possibly beyond, depending on how established certain nonnative species can become. Based on hydrological regimes presented in Figure 33, there is a 1 in 16 chance (6%) for the recurrence of a drought episode as previously described, with perhaps increased probability during extended drought.

The Humpback Chub in the upper basin appears to do well under the normal range of flows for the Colorado River, and periodic high flows appear to benefit the species by providing suitable conditions that result in strong year classes. However, episodic droughts stress canyon ecosystems, reduce survival and recruitment, and allow invasions of nonnative fish and competing Roundtail Chub. This condition is exacerbated by the persistence of nonnative predators, where an otherwise exceptionally high flow is required to limit their abundance in canyon-bound population centers.

The larger populations of Humpback Chub are clearly more resistant and resilient to these drought episodes because of the greater number of long-lived adults that provide storage of reproductive potential. The viability of the Humpback Chub in the upper basin will depend on the efficacy of flow management to moderate low flows during drought; as well as the efficacy of nonnative fish management to adequately control predators and competitors.

These relationships of flow to abundances of Humpback Chub, Roundtail Chub, and nonnative fish allow us to provide some reasonable projection of future Humpback Chub populations, given the current understanding of upper basin hydrology. Past hydrology, as shown in Figures 25 and 27, indicates that periodic episodes of drought are likely to reoccur. Knowing these relationships empowers managers to anticipate and offset periods of low flow, and accelerate efforts to regulate nonnative fish so that they don't expand into in Humpback Chub population centers, especially during years of low flow.



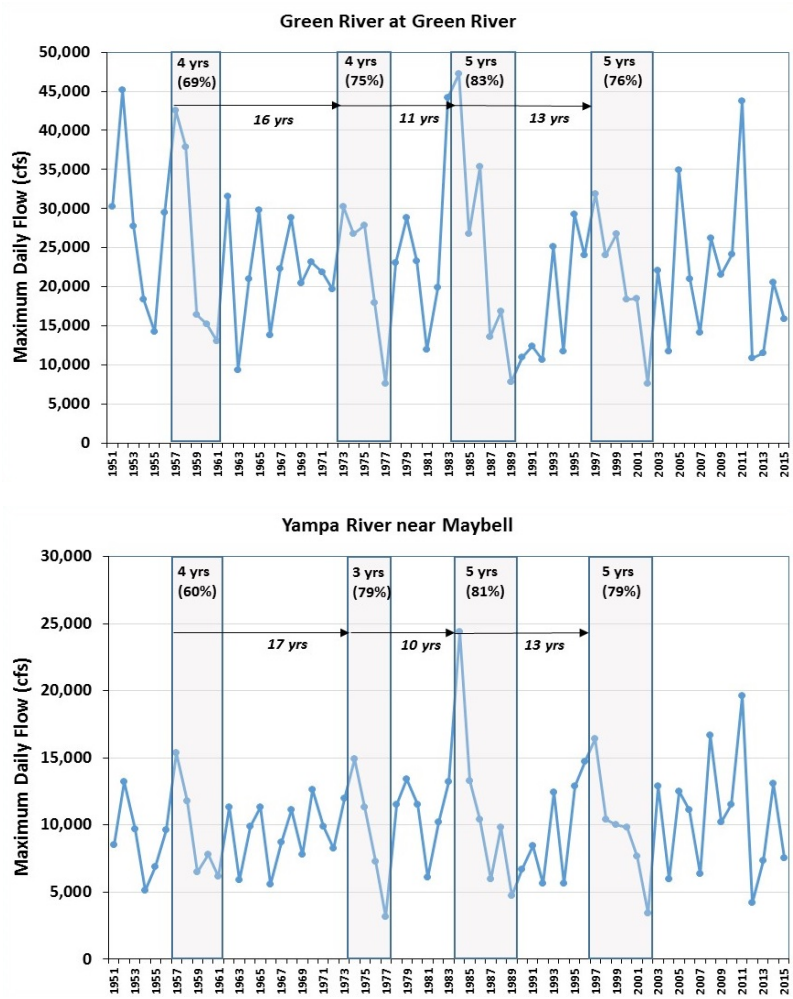


Figure 9. Maximum daily flow by year for 1951–2015 for the Colorado River near Stateline (USGS 09163500), Green River at Green River (USGS 09315000), and Yampa River near Maybell (USGS 09251000). Episodes of declining flow magnitude are highlighted by gray vertical bands with duration of each episode and percent decrease in peak flow indicated.

B.3 Lower Basin—The flow relationships analyses done in the upper basin were not done for Humpback Chub in the Grand Canyon, where flow is controlled within a predicable range, and the complexity of natural environmental correlates is confounded by multiple altered resources. Furthermore, investigations show that the species is affected differently in the LCR and in the mainstem Colorado River. Coggins et al. (2006) and Coggins (2008) explored prior survival and recruitment rates that led to the adult decline from 1989 to 2001, as well as to the increase in numbers after 2001 (see section 4.5.6), and determined that the population was driven by an interaction of flow, water temperature, food supply, and nonnative predators and competitors in the two systems.

Valdez and Ryel (1995) determined that production of age-0 Humpback Chub in the LCR, and subsequent recruitment to the mainstem, was driven by high spring flows in the LCR, as observed for a strong 1993 year class after a high flow, but that predation by Rainbow Trout and Brown Trout in the mainstem could eliminate an entire year class. VanHaverbeke et al. (2013) found a strong correlation between spring runoff for 2000–2012 in the LCR and fall age-0 CPUE ($n = 13$, $r = 0.755$, $p = 0.003$), which translated to high numbers in the mainstem (Finch 2012). Valdez and Kubly (2013) determined that average maximum daily discharge of the LCR for the period 1988–2000 was the lowest on record, which apparently led to low reproductive success and contributed to the 1989–2001 adult decline. Hence, as with the prior analysis of peak flow for the upper basin, the same phenomena was observed in the LCR, where production of Humpback Chub was linked to high spring flow.

Factors that affect the Humpback Chub population in the mainstem Colorado River differ from those of the LCR, primarily because the mainstem is a larger river system with cool water from dam releases. Dzul et al. (2017) developed a Bayesian state-space growth model to assess effects of temperature, turbidity, food availability, flow variability, and trout abundance on subadult Humpback Chub growth in the Colorado River and the LCR, by using out-of-sample prediction to rank competing models. Environmental covariates explained a high proportion of the variation in growth in both rivers; however, the best growth models were river-specific and included positive temperature and turbidity duration effects for the Colorado River and positive temperature and food availability effects for the LCR. These results quantify and confirm earlier observations by investigators related to the benefits of temperature (e.g., Coggins 2008; Finch 2012) and duration of turbidity (e.g., Valdez and Ryel 1995; Ward and Morton-Starner 2015) to juvenile Humpback Chub.

While the best Colorado River model included temperature and turbidity duration effects, it did not include effects of food availability, trout, and flow variability on subadult Humpback Chub growth. Importantly, the food availability metric did not include allochthonous inputs, which are an important source of food during flood events. Although neither trout nor food effects were included in the top model, the second model included a negative trout effect and a positive food effect, lending support to the hypothesis that trout compete with Humpback Chub. Trout abundance may affect food availability and thus exert indirect, long-term effects on chub growth that are difficult to detect (Dzul et al. 2017).

In the LCR, Dzul et al. (2017) also found that growth was highest when food availability was high but temperatures were moderate; i.e., 18°C is below the optimal growth temperature for Humpback Chub. The sparse data on food availability suggest a synchronous timing of high invertebrate emergence and high Humpback Chub growth rates. Furthermore, because the food availability metric did not include food items such as fish, larvae, or eggs, it may underestimate food availability in April and May when egg and larval production are at their peak and Humpback Chub have displayed cannibalism (Gorman and Stone 1999). Dzul et al. (2017) did not find an effect of turbidity on growth in the LCR, as reported earlier by Dzul et al. (2016).

The future condition of the Humpback Chub in the Grand Canyon appears favorable, but is clearly affected by a suite of variables with different interactions in the LCR and the mainstem, that lend some uncertainty to annual reproduction, survival, and recruitment. The following is a summary of the future condition of these variables and their likely effect on fish populations.

Relationship of Lake Powell Elevation to Dam Release Temperature— Temperature of the Colorado River through the Grand Canyon is influenced by Lake Powell inflow and elevation, temperature and volume of dam releases, time of year, and longitudinal downstream river warming. The hydrologic analysis for the LTEMP EIS was used to help assess future temperature for the Colorado River through Grand Canyon (U.S. Department of the Interior 2016, Appendix D: Hydrology Technical Information and Analysis). Projected temperature was derived from 21 traces each for 20 years (CY 2014-2033) at the confluence of the LCR (RM 62; Figure 34).

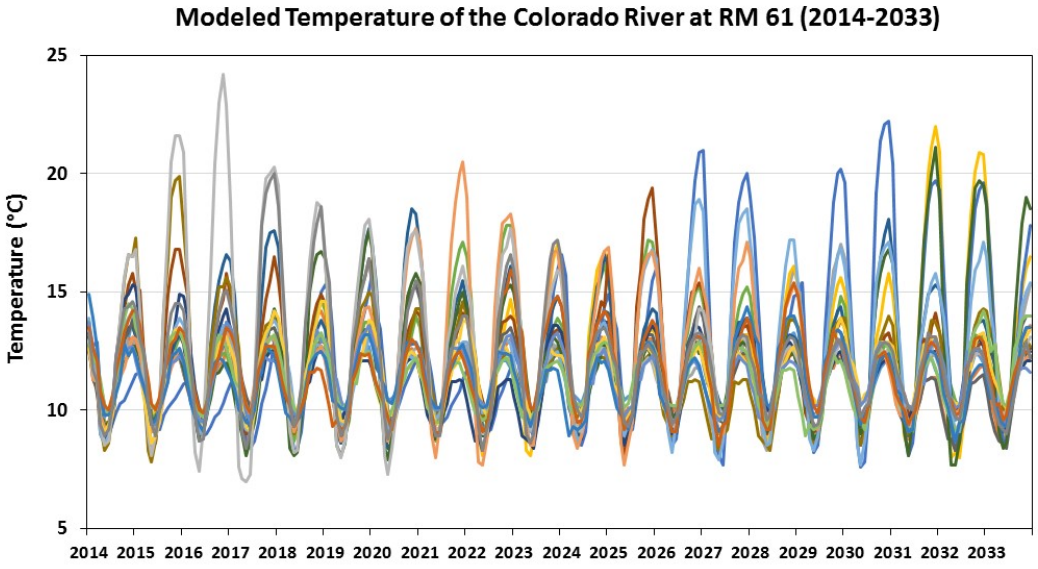


Figure 10. Projected mean monthly temperature of the Colorado River at RM 61, based on 21 traces each for 20 years (CY 2014-2033). Source: GCMRC; see U.S. Department of the Interior 2016, Appendix D: Hydrology Technical Information and Analysis.

A temperature duration curve for each of the years in the traces, as the sum of mean monthly temperature, was used to help identify the percent of time that a given temperature regime was likely to be equaled or exceeded in the future (Figure 35). The 25%, 50%, and 75% exceedance values were used to select a representative year for an analysis of future temperature and possible fish response with respect to timing of spawning.

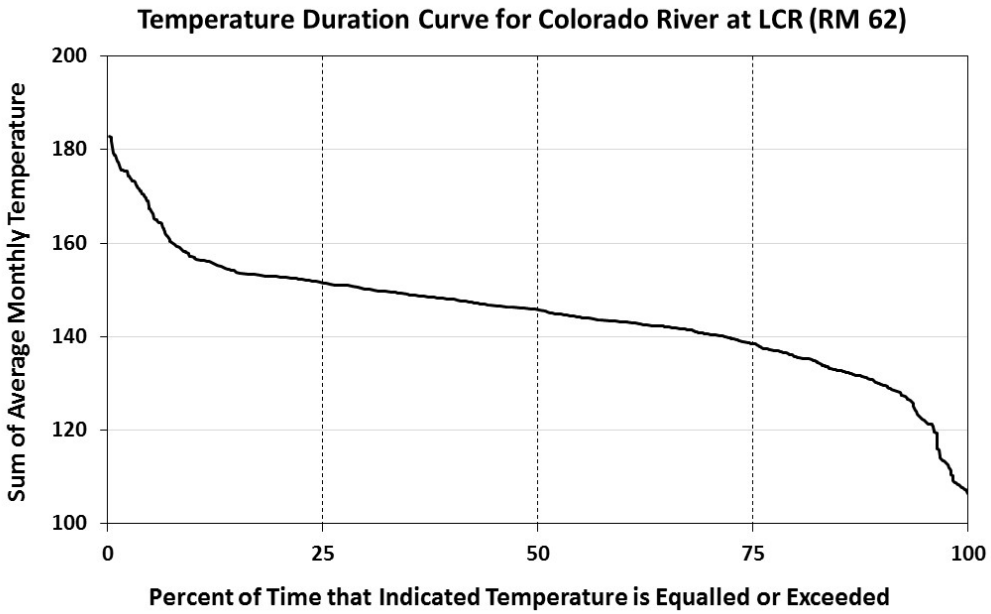


Figure 11. Temperature duration curve for the Colorado River at RM 62 (immediately downstream of the Little Colorado River). Curve is based on the sum of average monthly temperature for each of the years represented in Figure 33.

The annual thermographs are provided to illustrate the temperature for a pre-dam year (1960) and for representative years equal to 25%, 50%, and 75% exceedance for the Colorado River at Lees Ferry (RM 0), and immediately downstream of the LCR (RM 62), Havasu Creek (RM 157), and Diamond Creek (RM 226; Figure 36). River temperature at the various locations was determined with a model developed by Wright et al. (2008) that accounts for air temperature, water volume, time of year, and distance downstream.

The pre-dam thermograph characteristically peaked at ~25°C in July and dropped to near-freezing temperatures in January and December. The post-dam projected thermographs all indicate minimum temperatures of ~8–10°C from January to April upstream of the LCR. The thermograph equal to 25% exceedance is the warmest with maximum temperatures of 15, 16, 17, and 20°C in late August and early September at the four locations, respectively. The year of 50% exceedance is colder with maxima of 13, 14, 16, and 17°C, respectively, in October and November. For the most likely future thermograph at 75% exceedance, maximum temperatures of 11, 13, 15, and 17°C, respectively, are reached in August and September.

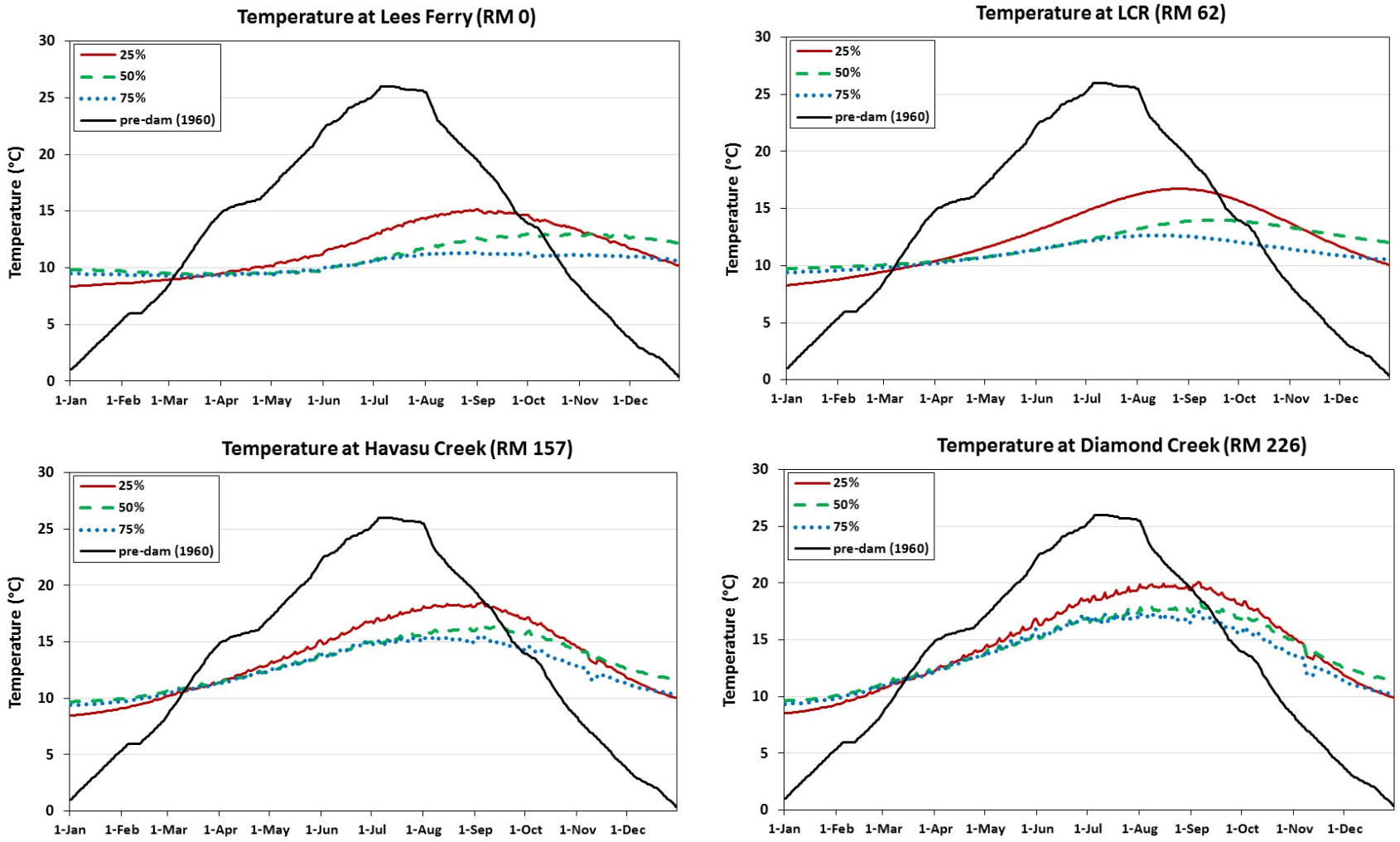


Figure 12. Colorado River temperature at Lees Ferry, and immediately downstream of the LCR, Havasu Creek, and Diamond Creek for pre-dam (1960), and representative years equal to 25%, 50%, and 75% exceedance of projected temperature.

This modeling shows that dam release temperature, even at low reservoir elevation, does not reach a maximum level until August to October, unlike the earlier pre-dam peak of July. This phenomenon of warmest releases in fall is caused by mixing during fall overturn; i.e., as the surface of the reservoir cools, the relatively warm water sinks and becomes entrained in the penstocks.

Warm dam releases occur earlier if the reservoir is low; however, lake elevation must be maintained at least 40 feet over the penstock elevation of 3,470 feet to avoid air entrainment and cavitation that impedes power generation, and the warmest surface water from the reservoir is not likely to become entrained. Another aspect of the post-dam thermograph is that water released from the dam and at downstream locations does not drop below ~7°C, and it never freezes as occurred during pre-dam flows.

Projected Response by Fish to Dam Release Temperature—The response by selected fish species of Grand Canyon to projected future river temperatures was evaluated with a temperature degree-day (TDD) model (Valdez et al. 2013). The model computes TDD by calendar year and compares the computed TDDs with estimated minimum TDDs required by species for spawning, incubation, and growth. This comparison provides a determination of whether one or more of these life stages is possible for a given annual thermograph and the dates in which the TDDs are met.

For the Humpback Chub, suitable TDDs for spawning occurred under pre-dam conditions during the month of April throughout the Grand Canyon (Figure 37). This is within the most likely time of historical spawning (mid-March to June), based on basin-wide observations of spawning for the species (see Table 2). For all future scenarios (25%, 50%, 75% exceedance), TDDs necessary for spawning are not reached at Lees Ferry, occur only for the 25% exceedance hydrograph at the LCR, but are suitable in Havasu Creek and Diamond Creek.

The model predicted suitable spawning conditions (TDDs) for the Humpback Chub at Lees Ferry as late as December because of the delayed warming of dam releases. The Humpback Chub is typically a spring spawner that is presented with sub-optimal temperature in spring, and it is unlikely that the species would spawn in late summer and fall. Further downstream, at the LCR, suitable TDDs are reached in June through mid-August, which is within the time frame observed for the species spawning in other parts of the basin (see Table 2). From about Havasu Creek downstream, temperatures are suitable for spawning under all projected temperature regimes. This is confirmed with recent collections and observations of fish of all ages and evidence of mainstem spawning in western Grand Canyon (see sections 3.1.1, 3.1.3, and 4.5.6).

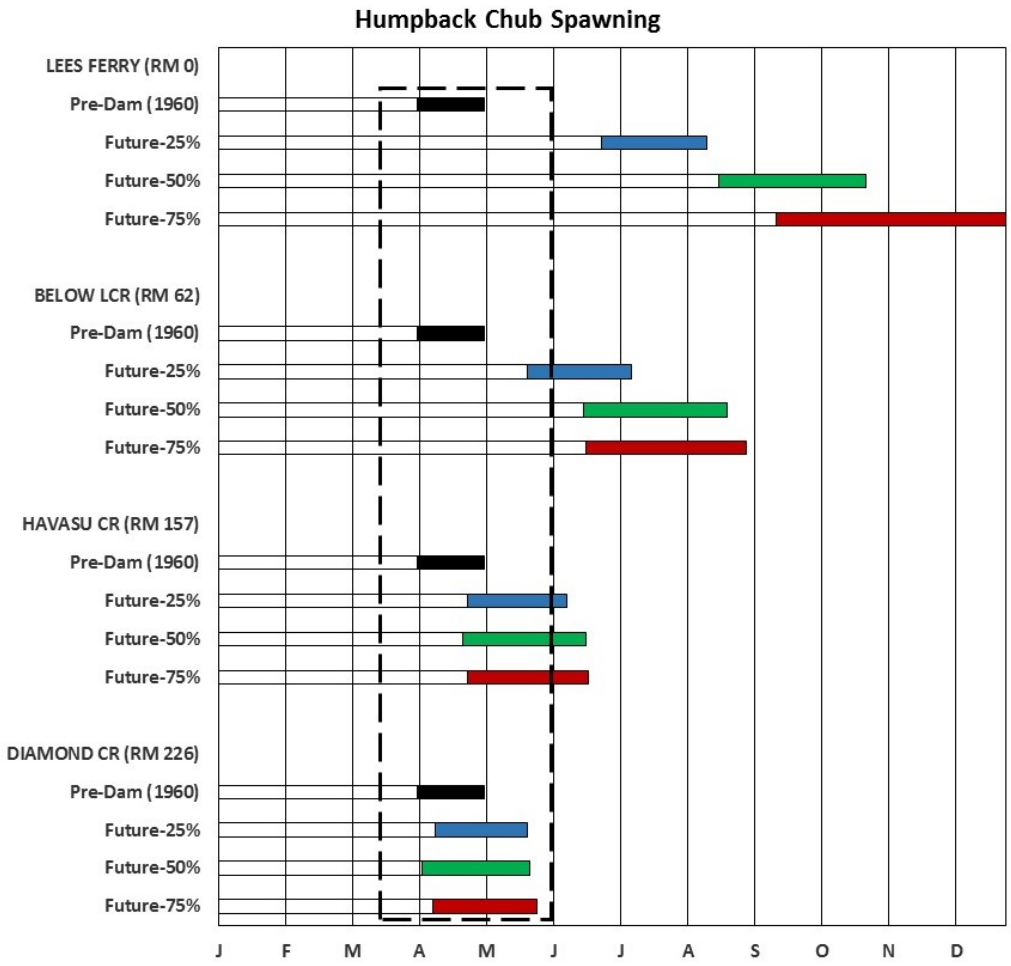


Figure 13. Projected timing of spawning for Humpback Chub during pre-dam (1960), representative years equal to 25%, 50%, and 75% exceedance of projected temperature. The length of each colored bar indicates the time when temperature is suitable for spawning; uncolored bars indicate that temperature is not suitable for spawning. Dashed boxes delineate most likely spawning time for the species.

A similar response is expected for three other native fish species in the Grand Canyon besides the Humpback Chub (Flannelmouth Sucker, Bluehead Sucker, and Razorback Sucker, Figures 38 and 39). If future condition is warm dam releases from lowered Lake Powell elevation (25% exceedance), conditions will continue to be unsuitable for spawning by any of the four native fishes at Lees Ferry, but will be suitable downstream of the LCR. For cooler releases (50% and 75% exceedance), TDDs for spawning will not be suitable for native species at Lees Ferry, marginally suitable at the LCR, and suitable in downstream locations. It is important to note that although temperature is important to these populations, other aspects of the river system are equally important, including food and the interactions with other species (Dzul et al. 2017).

The benefits of warm water can also extend to nonnative fish species that are predators and competitors of the Humpback Chub. Timing of spawning for six nonnative species (Brown

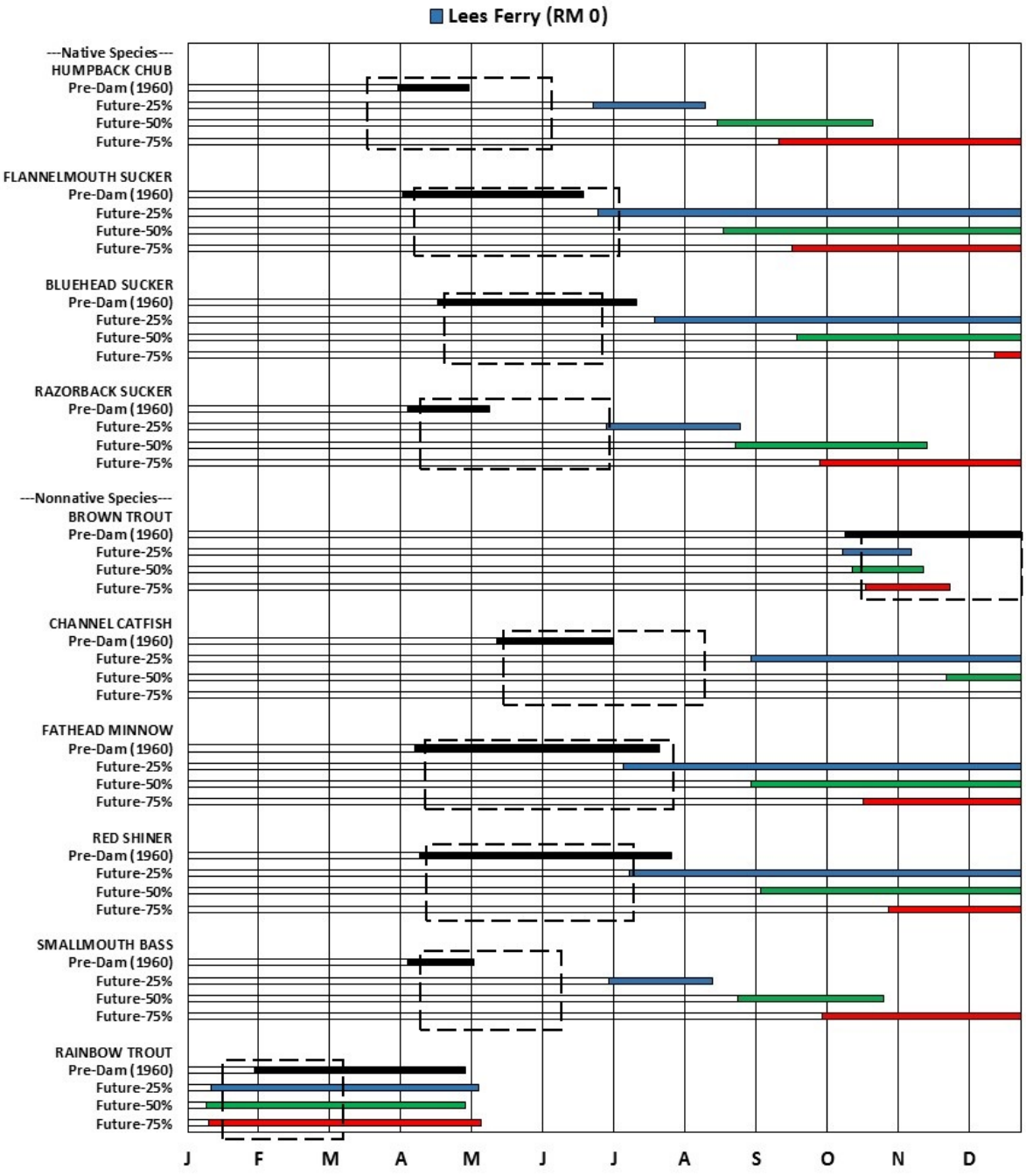
Trout, Channel Catfish, Fathead Minnow, Red Shiner, Smallmouth Bass, Rainbow Trout) at water temperatures for pre-dam (1960) and 25%, 50%, and 75% exceedance are also shown on Figure 38 and 39 for four locations downstream of Glen Canyon Dam. Suitable TDDs for spawning at warmest projected condition is reached at Lees Ferry only for the Rainbow Trout, but for all six warm-water species downstream of the LCR. The recent increase in Brown Trout in Lees Ferry, with evidence of reproduction, may be attributed to warmer fall releases combined with fall High Flow Experiments (HFEs; Brown Trout Workshop, September 21-22, 2017, Phoenix, AZ).

Projected temperature for Grand Canyon and modeled TDD suitability indicate that water temperature in Grand Canyon is likely to become increasingly suitable for spawning by the Humpback Chub—but also for key nonnative fish species, especially warm-water forms. This suitable temperature range is likely to occur downstream of the LCR starting in late May or early June, but advancing in time to early April at more downstream locations near Diamond Creek. The effect of future warming from low reservoir elevation will be spawning times in July for upstream reaches (LCR) and advancing to earlier times at downstream reaches (Diamond Creek) with longitudinal warming.

For the next 10–15 years, reservoir elevation and dam release temperature are not expected to change appreciably, but the long term is more uncertain. If the current pattern in reduced water availability continues and Lake Powell elevation drops to levels where the penstocks entrain epilimnetic water (e.g., 3,530–3,550 feet), warm water would flow into the Grand Canyon on an annual basis, though not with the same pattern as pre-dam condition. Instead, warm releases would mirror reservoir epilimnetic temperatures and produce 16–18°C as early as June and 20–23°C in mid-summer and early fall (Hart and Sherman 1996).

If the likely future includes epilimnetic dam releases, currently no mechanism exists to manage or mitigate this effect (e.g., temperature control device), and nonnative warm-water fishes could expand and present a substantial risk to Humpback Chub in the Grand Canyon. With Lake Powell elevation as a predictor of these conditions, it is imperative to develop detailed and effective nonnative fish management strategies to avert a large increase of predators and competitors that could lead to a decline in the Humpback Chub population.

Although these changes are expected to take place slowly over decades, with effects to fish populations that could become manifest over generations, a more dramatic effect is possible if threshold levels of temperature suitability are exceeded and a given fish species is suddenly and quickly able to successfully reproduce and recruit—such as the Smallmouth Bass in the Yampa River starting in the year 2000.


Lees Ferry (RM 0)
---Native Species---
HUMPBACK CHUB
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
FLANNELMOUTH SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
BLUEHEAD SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
RAZORBACK SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
---Nonnative Species---
BROWN TROUT
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
CHANNEL CATFISH
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
FATHEAD MINNOW
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
RED SHINER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
SMALLMOUTH BASS
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
RAINBOW TROUT
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
J F M A M J J A S O N D

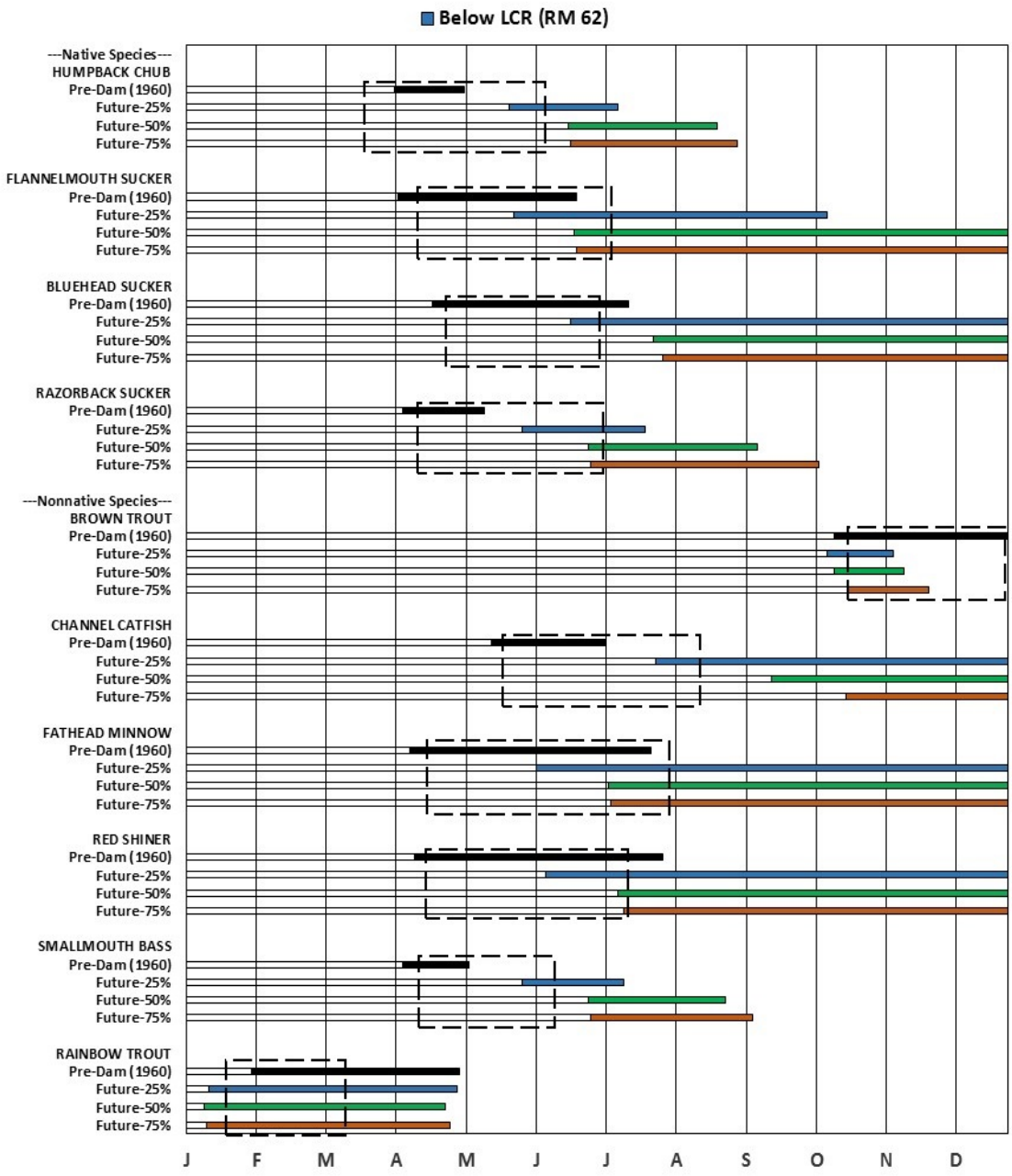
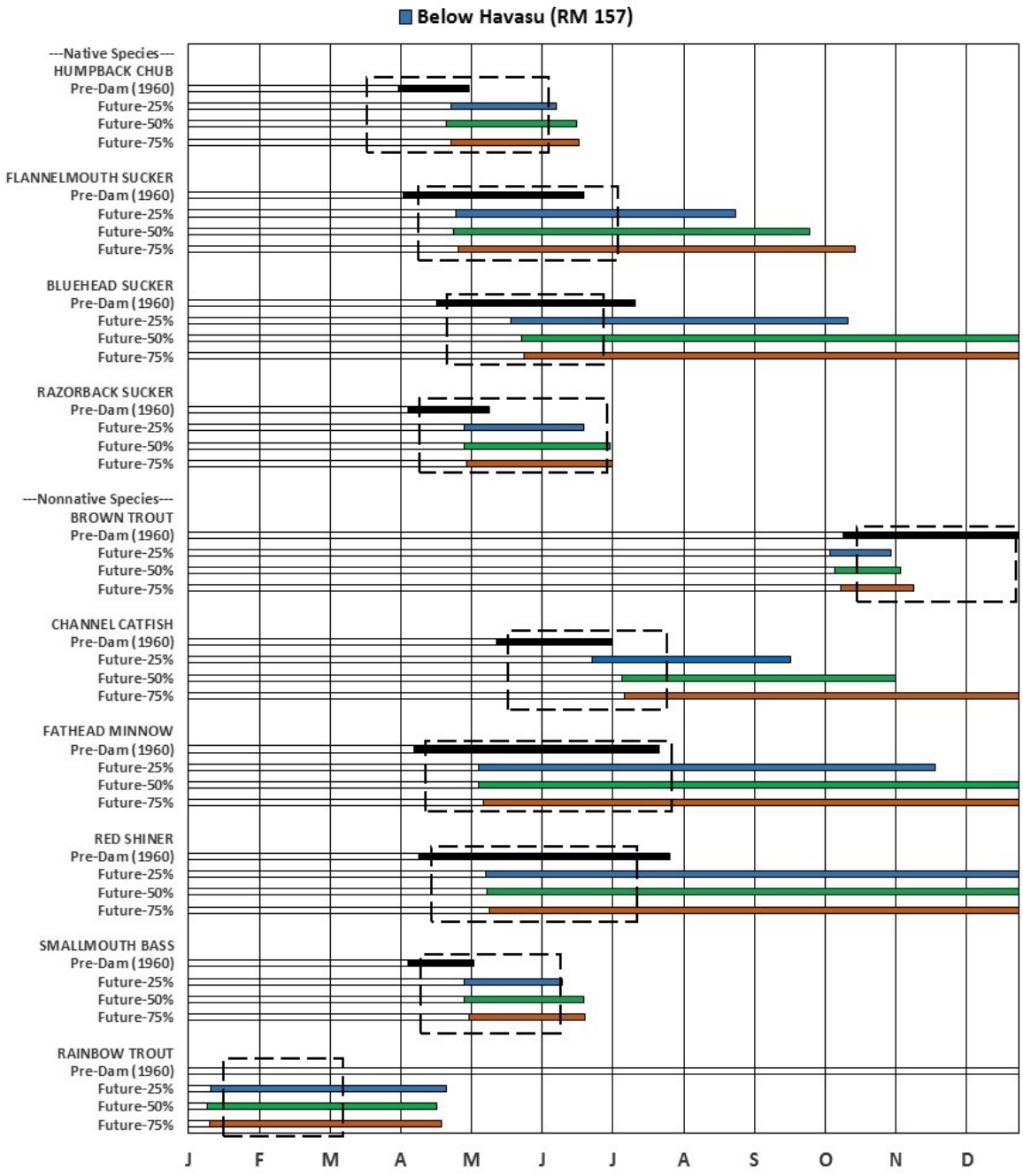


Figure 14. Timing of spawning at Lees Ferry and below the LCR for four native species (Humpback Chub, Flannelmouth Sucker, Bluehead Sucker, Razorback Sucker) and six nonnative fishes (Brown Trout, Channel Catfish, Fathead Minnow, Red Shiner, Smallmouth Bass, Rainbow Trout) at water temperatures for pre-dam (1960), and representative years equal to 25%, 50%, and 75% exceedance of projected temperature. The length of each colored bar indicates the time when temperature is suitable for spawning; uncolored bars indicate that temperature is not suitable for spawning. Dashed boxes delineate most likely spawning time by species.


Below Havasu (RM 157)
---Native Species---
HUMPBACK CHUB
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
FLANNELMOUTH SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
BLUEHEAD SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
RAZORBACK SUCKER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
---Nonnative Species---
BROWN TROUT
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
CHANNEL CATFISH
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
FATHEAD MINNOW
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
RED SHINER
Pre-Dam (1960)
Future-25%
Future-50%
Future-75%
SMALLMOUTH BASS
Pre-Dam (1960)
Future-25%
Future-50%
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RAINBOW TROUT
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Future-75%
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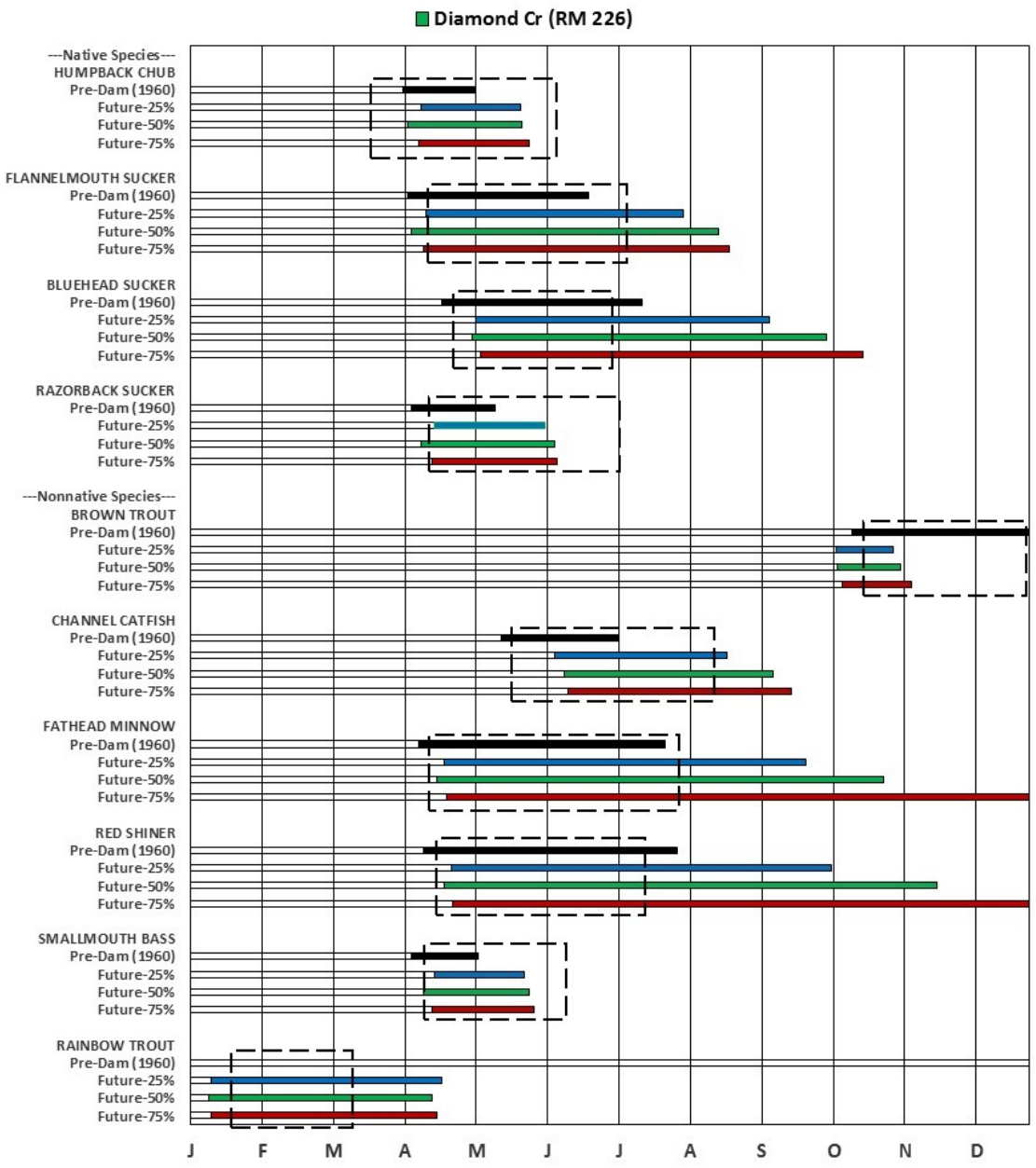


Figure 15. Timing of spawning below Havasu Creek and at Diamond Creek for four native species (Humpback Chub, Flannelmouth Sucker, Bluehead Sucker, Razorback Sucker) and six nonnative fishes (Brown Trout, Channel Catfish, Fathead Minnow, Red Shiner, Smallmouth Bass, Rainbow Trout) at water temperatures for pre-dam (1960) , and representative years equal to 25%, 50%, and 75% exceedance of projected temperature. The length of each colored bar indicates the time when temperature is suitable for spawning; uncolored bars indicate that temperature is not suitable for spawning. Dashed boxes delineate most likely spawning time by species.

APPENDIX C: Future Condition of Humpback Chub at 40-year timeframe

Chapters 5 and 6 evaluated the condition of the Humpback Chub 16 years into the future, a biologically meaningful timeframe based on the generation time for the species. To evaluate the risk to the species across longer timeframes, the U.S. Fish and Wildlife Service (USFWS) conducted additional analysis into the species condition up to 40 years into the future. This process provided consideration of the future condition of the species over additional generations, evaluated longer-term changes in resource condition, and incorporated the uncertainty of a longer-term future. Although this is a qualitative evaluation, it is strongly based on the Science Advisory Team's input concerning the current and future condition of Humpback Chub resource conditions, threat evaluations (primarily nonnative predators), and species population dynamics.

USFWS staff used the Science Advisory Subgroup's viability metrics at 0 years (current condition) and at 16 years for all three scenarios (future conditions) as the basis for projecting the future condition of Humpback Chub at 40 years. First, the viability metrics at 0 years and 16 years for all three scenarios were plotted. Existing tables in the SSA report (Table 7 for the current condition and Tables 19 and 20 for 16 years) supported these data points. Next, the data point for each scenario at 16 years was related back to the current condition (0 years) to create a 16-year trend line. Finally, the trend between the 0 and 16-year metric for each scenario was extrapolated out to 40 years (Figure 1). Extrapolations were linear for scenarios 2 and 3 and asymptotic for scenario 1. Scenario 1 was extrapolated with an asymptotic line because the Grand Canyon population would likely persist, but the overall species' redundancy and representation would be severely degraded by conditions in the upper basin.

In Figure 1, we also communicated uncertainty surrounding each future viability projection using a shaded area of the projection color. These bands of uncertainty are qualitative representations of the USFWS staff's judgment. That is, uncertainty bands are a communication tool, not based on quantitative information. The basis for increasing uncertainty after the 16 year biologically meaningful timeframe, as discussed in the SSA, is as follows:

- The population growth rate of several upper basin populations is uncertain;
    - Both the Black Rocks and Westwater Canyon populations declined in the early 2000s, but have apparently stabilized over the past decade. Confidence in the apparent stabilization is low to moderate, and more data points are needed; and
    - The Desolation and Gray canyons and Cataract Canyon populations persist, but available monitoring data are not sufficient to make claims of changes over time.
- Expansion of nonnative predatory species, especially Smallmouth Bass, could still occur in the upper basin. Future conditions (e.g. prolonged drought) could cause establishment or expansion of these or new nonnative species;
- The adequacy of the food base to support the Grand Canyon population is uncertain; and
- A warming trend in water released from Glen Canyon Dam presents a real risk of future nonnative species invasion in the lower basin.

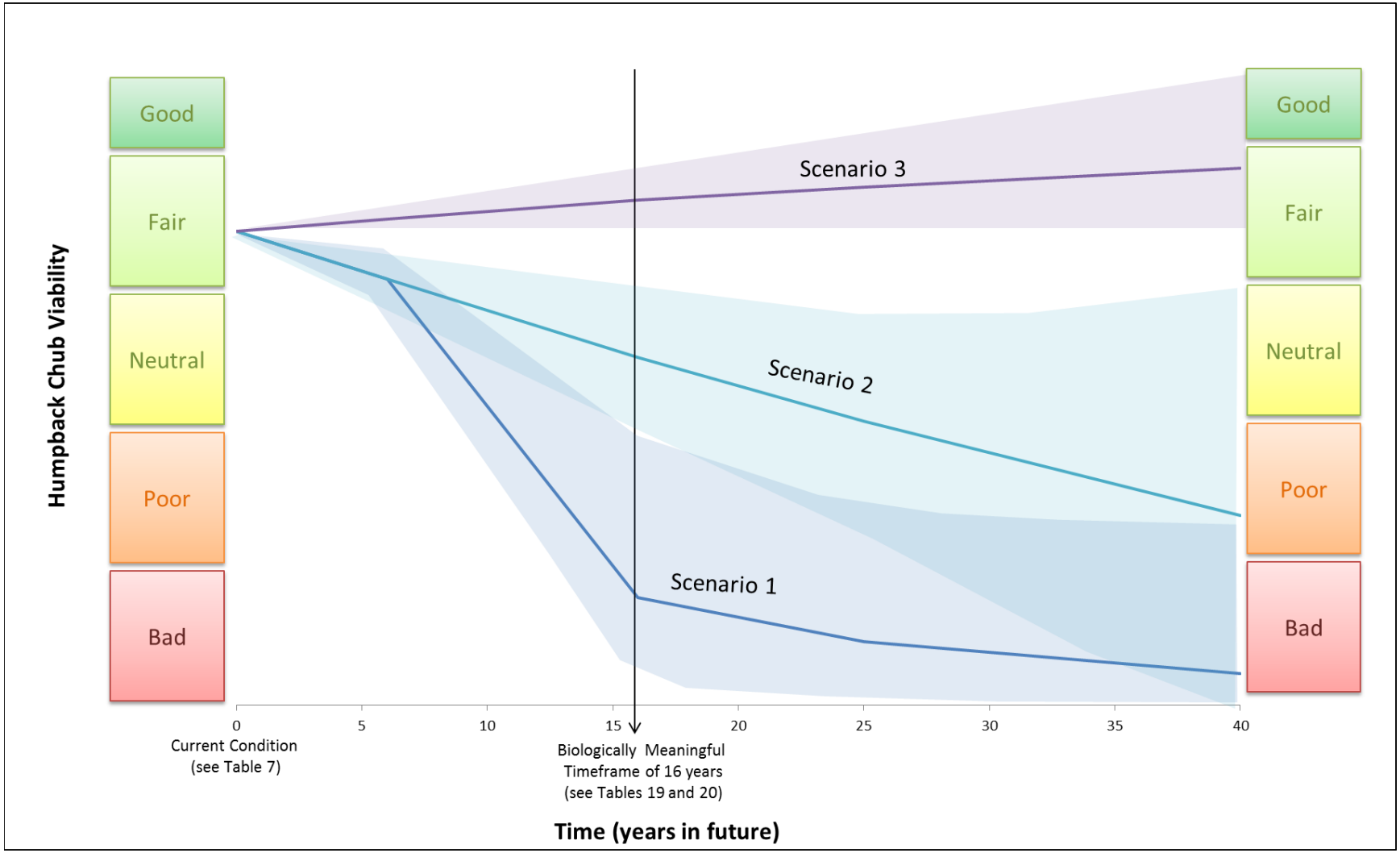


Figure 1. Humpback Chub viability projections forty years into the future. Data points at zero and 16 years are based on Tables 7, and 19 and 20 of the SSA report, respectively. Shaded area represents possible ranges of outcomes, communicating uncertainty of projections.

Summary of Scenarios Extrapolations to 40 years

Scenario 1, entitled "Environmental Stressors Increase and New or Discretionary Extralegal Actions are Eliminated", describes increasing threats and simultaneously diminishing management actions to only those required by law (such as under existing NEPA Records of Decisions). Importantly, this scenario includes a potentially significant downsizing of the collaborative partnership in the upper basin, the Upper Colorado River Endangered Fish Recovery Program (UCREFRP), when cooperative agreements expire in 2023[1], but recognizes the lower basin's Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) EIS's continued implementation. Under scenario 1, conditions degrade severely within both 16 and 40 years, primarily because of the unresolved future of the UCREFRP. Degraded resource conditions under scenario 1 could result in declining abundance in all upper basin populations, the possible loss of one or more upper basin populations, and potential declines in the Grand Canyon population. We chose to display this scenario with an asymptotic curve because the Grand Canyon population would likely persist, but both redundancy and representation would be severely degraded.

Scenario 2, entitled "Legally Mandated Management Actions and Additional Adaptive Management Actions (beyond those legally mandated) Continue at Current levels, but are Not Fully Effective at Mitigating Current and Potential Future Threats". This scenario describes increasing threats and correspondingly increasing management actions, but those actions are not fully effective at reducing impacts from reduced water and nonnative fish. This scenario recognizes the commitment of stakeholders to improving Humpback Chub resource conditions, but also acknowledges that there is uncertainty about management effectiveness. Under scenario 2, degradation of resources takes place (albeit at a slower pace than under scenario 1), even as conservation actions continue, resulting in neutral conditions within 16 years, but poor conditions within 40 years. Although there is large uncertainty of resource conditions under scenario 2 at 40 years, extrapolation of the conditions demonstrates a continuing decline in resource conditions. Scenario 2 could result in gradual declines throughout the upper basin and possible loss of an additional population; declines in the Grand Canyon population are less likely. If these declines continue for a substantial period of time, species redundancy and representation would be impacted.

Scenario 3, entitled "Legally Mandated Management Actions and Adaptive Management Actions (beyond those legally mandated) Occur, and Are Effective" describes increasing threats and correspondingly increasing management actions, and those management actions are effective at improving or maintaining resource conditions. If collaborative partnerships remain in place and their conservation actions are effective, as described under scenario 3, resource conditions improve at 16 and 40-year timeframes. Scenario 3 recognizes the commitment of stakeholders to improving Humpback Chub resource conditions and assumes we have the necessary tools to

[1] Note the divergent path of Scenario 1 upon expiration of the UCREFRP in 2023.

arrest resource degradation. Scenario 3 could result in stabilization and possible improvement in the upper basin populations; stable or increasing Grand Canyon populations are also likely.

The potential extirpation of multiple populations could most likely occur in the upper basin under the short 16-year timeframe in scenario 1 and the longer 40-year timeframe under scenario 2. The current health (resiliency) and distribution (redundancy) of all four populations (redundancy), coupled with sustained and adequate threat management, leads to species viability in the long term under scenario 3. Based on the current trajectory of several of the upper basin populations, the uncertainty associated with certain resource conditions, and the unresolved future of the collaborative partnership in the upper basin (the UCREFRP), species conditions and viability could severely degrade within 16 to 40 years depending upon which scenario occurs.

EXHIBIT 38

U.S. Fish and Wildlife Service

FINAL
August 2018

Species Status Assessment Report for the Razorback Sucker *Xyrauchen texanus*



U.S. Fish and Wildlife Service
Mountain-Prairie Region (6)
Denver, Colorado

PREFACE

This Species Status Assessment provides an integrated, scientifically sound assessment of the biological status of the endangered razorback sucker *Xyrauchen texanus*. This document was prepared by the U.S. Fish and Wildlife Service (USFWS) with assistance from state, federal, and private researchers currently working with razorback sucker. The writing team would like to acknowledge the substantial contribution of time and effort by fisheries biologists who participated in the Delphi survey reported in Section 6 of this Species Status Assessment and from those that participated in the Science Team for Scenario Development.

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Cover Photograph Credit

BIO-WEST, Inc.

Recommended Reference

U.S. Fish and Wildlife Service. 2018. Species status assessment report for the razorback sucker *Xyrauchen texanus*. U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

EXECUTIVE SUMMARY

This Species Status Assessment (SSA) provides an integrated assessment of the status and viability of the razorback sucker (*Xyrauchen texanus*) across eight populations. The SSA first establishes the essential requirements of razorback sucker by describing the species, its resource needs and the risk and conservation factors affecting it. Next, the SSA evaluates the current condition of the species through an assessment of physical habitat conditions and demographic responses under existing environmental and anthropogenic factors. To assess potential future condition, the SSA presents forecasts of razorback sucker response to multiple probable future scenarios under a biologically meaningful timeframe. Considering the uncertainties of each future scenario, the species is evaluated within the context of resiliency, redundancy and representation.

Species Overview

The razorback sucker (family Catostomidae) is a fish endemic to the warm-water portions of the Colorado River basin of the southwestern United States. Razorback sucker are found throughout the basin in both lotic and lentic habitats, but are most common in low-velocity habitats such as backwaters, floodplains, flatwater river reaches and reservoirs. Razorback sucker prefer cobble or rocky substrate for spawning, but have been documented to clear sediment away from cobble when conditions are unacceptable and even spawn successfully over clay beds. Depending on the subbasin, juveniles and adults frequently have access to appropriate habitat throughout the system ranging from backwaters and floodplains to deep and slow-moving pools, however nonnative fishes are frequently found in such habitats as well. The species is tolerant of wide-ranging temperatures, high turbidity and salinity, low dissolved oxygen and wide-ranging flow conditions. Razorback sucker typically become sexually mature between three and four years of age, can live for more than 40 years, and spawn multiple times over a lifespan. Razorback sucker consume a large array of food items depending on the environment in which they live.

The historical range of the species includes most of the Colorado River basin, from Wyoming onto the delta in Mexico, including the states of Colorado, Utah, New Mexico, Arizona, Nevada and California, and Mexican states of Baja and Sonora. In the upper Colorado River basin (UCRB or ‘upper basin’, defined here as upstream of Lees Ferry, Arizona), dam construction reduced peak flows, changed temperature regimes, and disconnected floodplains from the mainstem. Reduced peak flows caused vegetation encroachment and altered flow regimes, allowing a variety of introduced nonnative fishes to flourish. In this altered environment, recruitment of razorback sucker ceased, resulting in populations solely comprised of older adults. Captures of adult fish in the upper basin rapidly declined as adult mortality was not offset by active recruitment, so some remaining individuals were brought into hatcheries in the 1990s and propagation programs were developed. In the lower Colorado River basin (LCRB or ‘lower basin’, defined here as downstream of Lees Ferry, Arizona), dam construction had similar effects on habitat. While the reservoirs that resulted from dam construction initially supported some of the largest populations of razorback sucker (>70,000 individuals), these populations gradually declined as nonnative sportfish became abundant in the reservoirs. In response to population declines, razorback sucker were collected in the lower basin in the 1980’s to create augmentation programs. The razorback sucker was listed as an endangered species in 1991.

Stocking and reintroduction programs have allowed the species to persist despite a chronic lack of wild recruitment to the adult life stage in most populations. Stocking programs have succeeded in reintroducing adults that survive current ecological conditions and fulfill their ecological role. Stocked razorback sucker successfully reproduce in portions of both basins and have expanded such that populations are now present in much of previously occupied habitat, with the exception of the Gila River system. This SSA evaluates the species in eight geographic areas representing populations including four in the UCRB (Green River, Colorado River, San Juan River and Lake Powell) and four in the LCRB (Lake Mead, Lake Mohave, the Colorado River between Davis and Parker dams [Lake Havasu], and the Colorado River downstream of Parker dam). The Gila River is not evaluated here because a resident population has not been established, despite various stocking efforts.

Species Needs

We divided the life cycle of razorback sucker into five stages including eggs, larvae, juveniles, adults and spawning adults. During each life stage, razorback sucker require certain resource conditions. This SSA summarizes the following eight resource categories, which are considered the most important:

1. Complex lotic and/or lentic habitat available to razorback sucker *(Individual need)*
2. Suitable water temperature and quality (*Individual need*)
3. Variable flow regimes in lotic systems *(Individual need)*
4. Adequate food supply *(Individual need)*
5. Range and connectivity *(Species need)*
6. Population size *(Population need - resiliency)*
7. Multiple interconnected, naturally recruiting, and resilient populations *(Species need - redundancy)*
8. Genetic diversity *(Species need - representation)*

Risks and Conservation Factors

In addition to species needs, the SSA outlines risks (or stressors) and conservation actions that are currently affecting the species condition and are anticipated to do so in the future. Identified risks include climate change, genetic factors (hybridization, reductions in diversity [e.g. inbreeding]), changes in habitat (flow regime/connectivity, land use, habitat availability, water temperature), and nonnative and invasive species (predation, competition and habitat degradation). Overutilization, parasites, diseases, and pollutants were also considered, and although they were considered risks, were determined to be least impactful. Ongoing and future

conservation actions are interrelated and include water management, recovery and conservation program management and funding (including habitat development and management), nonnative species removal, research and monitoring, and hatchery-based augmentation.

Current Condition

The current condition for razorback sucker is determined by considering resource conditions, current risks and management actions, and the demographic response of populations. Resource and demographic conditions were qualitatively assessed by a Science Team comprised of representatives from each state in the species' range and involved federal agencies. Resource conditions were categorized using four levels ranging from high (generally highest condition currently available on the landscape and not representative of pre-human conditions) to extirpated (conditions representative of what would cause species extirpation) with two intermediate categories of medium and low. Interpretations of these levels are presented in Tables 4 and 5 in the text for each resource and demographic category.

Resource conditions in the UCRB are generally categorized as in high to medium condition when examined in isolation of other parameters. The exception is the presence of nonnative fishes in habitat, which is in low condition for most populations. The categorization of nonnative fish presence in habitat is designed to assess the degree to which habitat becomes unavailable to razorback sucker because of predation from or competition with nonnative fishes (Table EX1; details in Table 6 in section 5.1). The Green and Colorado river subbasins are categorized similarly, but flow variability, temperature regulation, and the availability of naturally functioning floodplain habitats are superior in the Green River. The San Juan River has fewer nonnative fish established in the basin, but less variability in habitat, variable flow and less connectivity because of the formation of a waterfall that blocks all upstream movement from Lake Powell into the San Juan. Physical resource conditions in Lake Powell are thought to be sufficient for the species, but large-bodied nonnative predators are abundant in the reservoirs. Lake Powell is the least studied system in the upper basin; substantial uncertainty remains for both physical resource condition and demographic response.

Resource conditions in the LCRB range from high to low when examined in isolation of other parameters, except for nonnative presence in habitat, which was classified as in extirpated condition for all populations except Lake Mead and the Grand Canyon (Table EX1; details in Table 7 in section 5.2). Competition and predation from nonnative predators, which is exacerbated by lack of cover and turbidity, prevents recruitment in all populations except Lake Mead. Flows in the lower basin are modified by water management and hydropower and typically lack flow variability. Contrary to the other systems, the habitat, temperature and food resources in the Grand Canyon were considered low, while nonnative presence in habitat was ranked high as native fish dominate the ecosystem. Habitat, water quality, temperature and food are thought sufficient for all other populations. The geographical ranges in the lower basin reservoirs are large and often include upstream riverine systems. Multiple congregations of fish occur within each population and movement between systems is restricted only by the presence of nonnative predators. The Colorado River population below Parker dam is limited to a section of river where multiple populations have not established. Mainstem dams prevent upstream movement and limit connectivity between populations.

Table EX1. Summary of physical resource current conditions (high condition [generally representing the highest condition currently available] is represented by green, medium condition by yellow, low condition by orange, and extirpated condition [conditions under which extirpation of the species would be expected] is represented by red; condition categories are more explicitly defined in Table 4 in the text). Gray boxes indicate lentic systems where variable flow is not assessed. Lake Powell colors are also shaded in gray to indicate a higher level of uncertainty.

	Physical Needs					
	Complex Habitat					
Population	Habitat	Nonnative presence in habitat	Water Quality/Temp	Variable flow (lotic only)	Adequate Food	Range & Connectivity
Green River Subbasin						
Colorado River Subbasin						
San Juan River Subbasin						
Lake Powell						
Lake Mead						
Grand Canyon						
Lake Mohave						
Lake Havasu						
Colorado Mainstem Below Parker Dam						

Current demographic conditions for the UCRB and LCRB are shown below (Table EX2; details in Tables 12 and 13 in section 5.3). The Green River subbasin currently holds the largest population of adult razorback sucker, which consists almost entirely of hatchery-reared individuals. Adults spawn annually at multiple locations and juvenile recruitment has been documented in floodplain wetlands in the Green River subbasin in each of the past five years. However, recruitment to the adult life-stage is rare, resulting in a low condition for that category. The adult razorback sucker population in the Colorado River subbasin has been increasing over the last decade through stocking efforts. Spawning and larval presence have been documented in the mainstem Colorado and tributaries above the confluence with the Green River. Untagged juveniles and adults have rarely been encountered, indicating that recruitment is not commonly occurring. Because recruitment in both systems is uncommon, monitoring efforts are not directed at this life stage. In both the Green River and Colorado River subbasin populations, a lack of recruitment is considered a result of nonnative predation and lack of access to rearing habitat. The San Juan River subbasin population has been consistent in size, but also consists almost entirely of hatchery-reared individuals. Spawning and larval production has occurred annually for the last 20 years, but there are indications that only a small percentage of the population is spawning. Juvenile recruitment has rarely been documented. A large population of nonnative channel catfish exists in the San Juan subbasin, but other large-bodied predators have not become established. A waterfall has recently formed on the San Juan River preventing upstream movement of fish from Lake Powell into the San Juan subbasin. The Lake Powell population of

razorback sucker is not stocked directly but is comprised of individuals stocked in the other three river subbasins. Additional research is needed to determine the source of high levels (19% or more) of untagged adults in Lake Powell. Despite the presence of adult razorback sucker across the UCRB, the populations are not self-sustaining and are dependent on continued stocking effort. In the absence of wild recruitment or continued stocking efforts, the populations would decline to extirpation.

Table EX2. Summary of demographic current conditions (high condition [generally representing the highest condition currently available] is represented by green, medium condition by yellow, low condition by orange, and extirpated condition [conditions under which extirpation of the species would be expected] is represented by red; condition categories are more explicitly defined in Table 5 in the text). Gray boxes indicate lentic systems where variable flow is not assessed. Lake Powell colors are also shaded in gray to indicate a higher level of uncertainty.

	Demographics					
Population	Adult population	Spawning and larval Presence	Recruitment	Dependence on Stocking	Genetic integrity	Population Stability
Green River Subbasin						
Colorado River Subbasin						
San Juan River Subbasin						
Lake Powell						
Lake Mead (and Grand Canyon)						
Lake Mohave						
Lake Havasu						
Colorado Mainstem Below Parker Dam						

In the LCRB, razorback sucker are actively recruiting in Lake Mead despite abundant nonnative fishes and lack of active management, leading to high condition scores for most demographic categories (Table EX2; details in Table 13 in section 5.3). The razorback sucker population in Lake Mead is small (approximately 500 adults) which is not thought to be sufficient to maintain genetic integrity long-term prompting a lower rating in that category. The three remaining razorback sucker populations (Lake Mohave, Lake Havasu, and below Parker Dam) in the LCRB are managed using stocking to maintain populations in the presence of nonnative predators. Larvae are collected annually from Lake Mohave (which also serves as a genetic refuge), reared in off-channel ponds or hatchery facilities and reintroduced as adults. Lake Havasu and the Colorado River below Parker Dam are stocked using traditional methods. These are successful strategies, however without continued reintroduction, these razorback sucker populations would become extirpated. The Colorado River between Davis and Parker dams (Lake Havasu) is home

to a repatriated population of razorback sucker and currently contains the largest population in the lower basin. The mainstem Colorado River below Parker Dam is actively stocked, but survival is low, resulting in populations too small to measure.

Current Viability

Resiliency

We use summaries of current condition to assess resiliency in each population. To summarize current condition, we averaged the classifications presented above using values of 3 for high condition, 2 for medium condition, 1 for low condition and 0 for extirpated condition[1]. When all habitat and demographic conditions were averaged for each population (Table EX1 and EX2), population resiliency is classified as medium (scores of 1.51 to 2.25) for all populations with the exception of the Colorado River below Parker dam, which was categorized as low (between 0.76 and 1.5). The classifications represent our understanding of the range of physical and demographic conditions currently found on the landscape. When only demographic conditions were used, Lake Mead was classified as high, the Green River subbasin was classified as medium, Colorado and San Juan river subbasins, Lake Powell, Lake Mohave, and Lake Havasu were classified as low and the Colorado River below Parker dam was classified as extirpated (Figure EX1).

We use averages of only demographic conditions to describe resiliency. Lake Mead has the highest resiliency in the system as the only population in which razorback sucker regularly complete all life stages despite abundant nonnative fishes, proving resiliency in the face of threats; however, the population size is small, causing genetic concerns that may require future management intervention. The high categorization is not meant to be representative of pre-anthropogenic conditions, to imply that conditions cannot improve or that the resiliency currently on the landscape is independent of management efforts. Razorback sucker across the Colorado River basin are actively managed and the resiliency presented here is dependent on those actions. The Green River is in the medium category because of resiliency in certain life stages (e.g. large population size, high spawning and larval presence and consistent recruitment to the juvenile stage with management). Populations are present, spawning and migrating in seven of the eight populations, though many at abundance levels dramatically lower than they were historically. Without continued management efforts, all populations would eventually decline to an extirpated condition and those in low or extirpated condition would decline more rapidly.

[1] Summary scores for resiliency are colored using the following matrix: 0-0.75 represents extirpated, 0.76-1.5 represents low, 1.51-2.25 represents medium and 2.26-3 represents high.

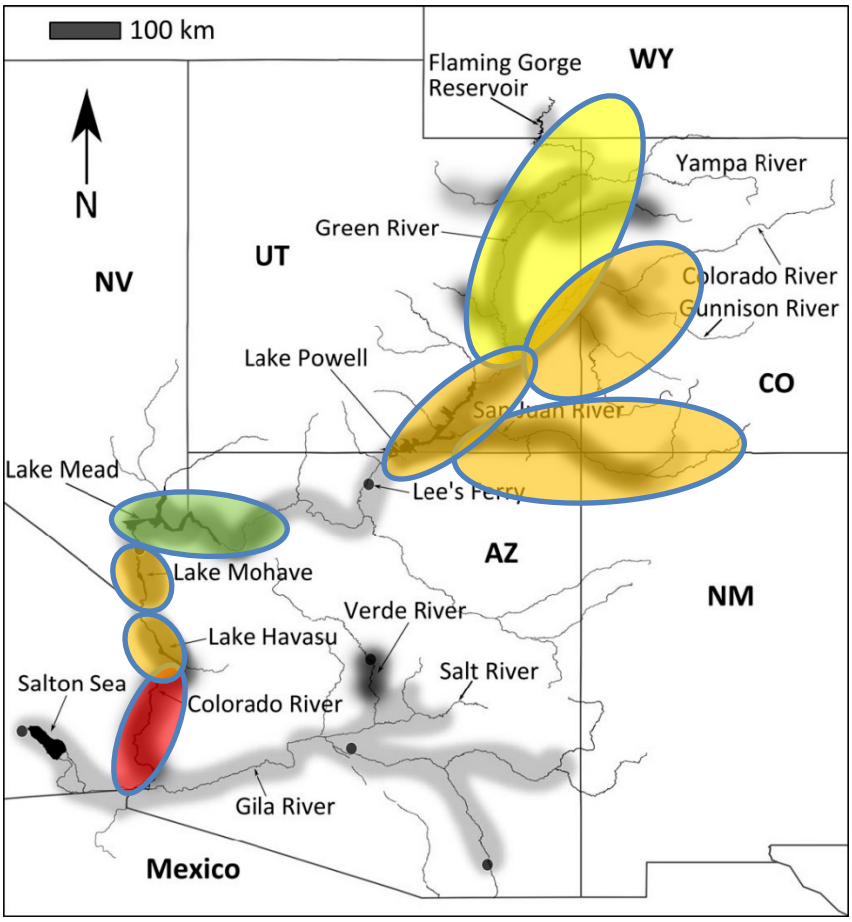


Figure EX1. Historical (light gray highlight) and current (dark gray highlight) distribution of the razorback sucker in the Colorado River basin with populations colored with the average of current demographic condition. High condition is indicated by green, medium condition is indicated by yellow, low condition is indicated by orange, and extirpated condition is indicated by red.

Representation

Razorback sucker have shown a high degree of plasticity in their ability to inhabit both lotic and lentic habitats and survive a wide range of environmental conditions. After populations were dramatically reduced in the upper basin, stocked individuals have shown an ability to spawn and migrate. Genetics of upper and lower basin populations are managed and therefore genetic diversity has been maintained. Lower basin populations, especially in Lake Mohave, show higher genetic diversity and less relatedness than upper basin populations (Dowling *et al.* 2012). Some hybridization occurs with other native and nonnative suckers, but currently at low levels. Genetic representation both within and among populations is high, but genetic adaptability will remain low as long as stocking is required to maintain populations as adaptive genetic traits are not passed from one generation to another through natural recruitment.

Redundancy

Razorback sucker are widely distributed across the Colorado River basin, occurring in multiple habitat types and likely to withstand local or even regional catastrophes. The high genetic

diversity present in Lake Mohave is distributed throughout the lower basin through larval collections and subsequent stocking, providing redundancy. Like resiliency, this redundancy is based on management actions, as most populations contain almost exclusively stocked individuals. Recolonization of catastrophically affected areas would like occur through direct or indirect stocking efforts. Stocked adults commonly migrate between populations in the upper basin. In the Green and Colorado river subbasins, most major barriers have been removed or their effects ameliorated by fish passage structures. Barriers to upstream movement remain in the San Juan river subbasin, although fish stocked in the San Juan have been documented in Lake Powell and the Green and Colorado rivers. Stocked individuals are routinely documented to move long distances expanding into appropriate habitat across the basin. Razorback sucker in lower basin populations congregate in specific inflow or spawning areas around the lake, and have been shown to migrate between those areas. However, upstream movement is blocked between populations. Should an entire population be eliminated, management actions would need to support reestablishment of the species in those areas.

Evaluation of Future Condition

The future condition of the razorback sucker is derived by considering future resource conditions for each population under five scenarios.

To define the bounds of future conditions, a Delphi process was used to survey a group of species experts to rank the most impactful risks and conservation actions over the next 30- and 100-year periods. Three factors were weighted highest for the 30-year period: nonnative predation, flow regime and water management. A second tier included conservation and recovery efforts: program funding, augmentation, nonnative removal, and research and monitoring. The results were similar over the 100-year period, but climate change was predicted to be of greater concern than it was over the 30-year period. For this SSA, the future condition scenarios are evaluated at a timeframe of 30 years, which corresponds to approximately three razorback sucker generation times.

Based on these results and the substantial impacts of management on razorback sucker, the Science Team assessed future condition scenarios based on the effectiveness of management actions. The scenarios include two worst-case scenarios representing least successful conservation and augmentation programs (scenarios 1 and 2), a status quo (scenario 3), and two best-case scenarios representing the possibility of establishing naturally recruiting populations (scenarios 4 and 5). All scenarios assume higher water temperatures and lower water availability in the system as a whole. For each of the potential future scenarios, the Science Team members individually predicted the overall effect of a scenario within each population using best professional judgement as described in section 6.2. Predictions of future condition of the species demographic needs were averaged across needs and across participants and are presented in Figure EX2, with details provided in Figures 33 – 42 and in sections 6.2.1-6.2.5.

- Scenario 1 – Recovery and conservation actions for razorback sucker are reduced to minimal levels because of funding reductions or program expiration. This scenario assumes elimination of some active and adaptive management actions, and reduction in voluntary management actions for the species, such that many actions are no longer in place to mitigate

decreased water availability, future water development, or nonnative fish pressures. This scenario assumes dramatic downscaling of upper basin programs but assumes funding and continuation of lower basin programs through the timeframe(s) considered.

- Upper basin populations – management of streams flows would decline, nonnative fish populations expand; adult population of razorback sucker would decline to extirpation at varying rates.
- Lower basin populations – habitat and flow conditions would like remain similar to current condition, adaptive management may slow or cease, causing decreases in all populations except Lake Mead.
- Resiliency, redundancy and representation all decline to extirpation.
- Participants predicted likelihood of this scenario to be unlikely in the 30-year period, but about as likely as not over 100 years.

- Scenario 2 – Recovery actions continue at levels thought to be beneficial to the species as are currently in place, but augmentation efforts are less effective than currently observed which results in a reduction in survival of stocked fish. Overall effectiveness of recovery actions is below current success levels.
  - Upper basin populations – management of stream flows, wetlands, screens, and nonnative fishes would continue; reduced survival in stocked fish would prompt declines in all populations; the Colorado and San Juan river subbasins would likely reach extirpation, the Green River subbasin and Lake Powell would fall at least to low condition.
  - Lower basin populations – lack of effective augmentation would cause extirpated conditions in Lake Mohave and the Colorado River below Parker dam, threatening representation. The populations in lakes Mead and Havasu would decline, with the Havasu population reaching low condition.
  - Declines expected in resiliency, redundancy and representation.
  - Participants predicted likelihood of this scenario to be about as likely as not in the 30-year period, and likely over 100 years.

- Scenario 3 (status quo) – Recovery and conservation actions continue at levels thought to be beneficial to the species (including legally required actions and adaptive/voluntary efforts currently in place) and are effective at reducing some threats. This scenario represents continuation of the status quo and the effectiveness of recovery actions as we currently understand them.
  - Upper basin populations – increases in condition are expected in all populations, but remaining threats are persistent, limiting possible gains. Minimal recruitment is expected in some populations, but not enough to exceed adult mortality.
  - Lower basin population - small increases in condition are expected, potentially from improved stocking success. Dramatic gains are prevented by nonnative species remaining abundant in all populations, limiting effective population size. Wild recruitment is not expected.
  - Improvements in resiliency are expected in some populations.
  - Participants predicted likelihood of this scenario to be very likely in the 30-year period, and likely over 100 years.

- Scenario 4 – Recovery actions continue at levels thought to be beneficial to the species (including legally required actions and adaptive/voluntary efforts currently in place) and are effective at reducing threats to a level supporting active recruitment, more than is currently realized. This scenario assumes reduction of current stressor(s) affecting populations.
    - Upper basin populations – assumes effective management of multiple floodplain wetlands or an increase in effectiveness of nonnative fish controls, producing year classes of wild fish sufficient to recruit. Increases in condition are expected in all upper basin populations driven by recruitment success, resulting in reduced stocking levels.
    - Lower basin populations – assumes creation of off channel wetlands or methods to protect razorback sucker habitat from nonnative fish predation in reservoirs, resulting in an increase in recruitment in Lake Mohave or Lake Havasu, but not at levels sufficient to reduce stocking efforts.
    - Resiliency of populations would increase, coupled in increases in redundancy.
    - Participants predicted likelihood of this scenario to be unlikely in the 30-year and 100-year periods.

- Scenario 5 – Improved recovery actions support wild populations of razorback sucker (includes legally required actions plus adaptive and voluntary efforts currently in place) and are effective at reducing most threats in the system. This scenario assumes improved effectiveness of recovery actions (effective basin wide nonnative fish suppression, rearing habitat management) to a level where recruitment completely sustains the populations.
    - Upper basin populations – all populations reach high condition in this scenario as a result of nonnative fish removal (instead of control) and establishment of sufficient juvenile habitat.
    - Lower basin populations – all populations reach medium condition in the scenario as a result of removal/control of at least some nonnative predators in reservoirs.
    - Resiliency would dramatically improve in all populations and redundancy would improve as populations grow. Representation would no longer be management based.
    - Participants predicted likelihood of this scenario to be very unlikely in the 30-year period and unlikely over 100 years.

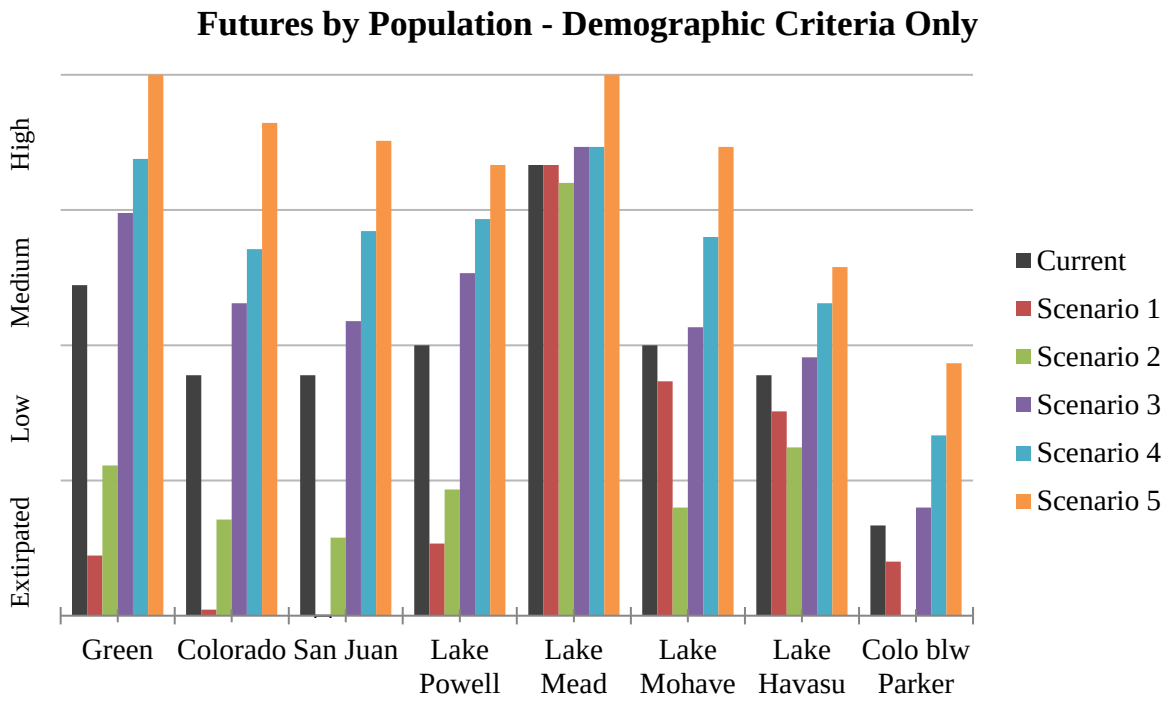


Figure EX2. Predicted response in demographic needs for razorback sucker under future scenarios 1-5.

Future Viability

The results of the management-based future scenarios predict future conditions ranging from restoration of populations to a high condition to returning to the low condition seen in the last half century (Figure EX3). Multiple management actions have been taken to date to improve razorback sucker populations from previous low levels in the UCRB. Flow recommendations have been developed and implemented to ensure flows mimic the natural hydrograph to the extent possible. Fish screens and fish passages have been constructed to prevent entrainment in canals and allow for migration of native species across the basin. Management of floodplain wetlands has produced young-of-year razorback documented to survive their first year of life. Stocking of razorback sucker and removal of nonnative fishes occur annually. These management actions have improved resiliency of populations, created redundancy and maintained representation. Continuation of these management actions is likely to continue the gains in resiliency while cessation of management actions is likely to threaten resiliency, redundancy and representation.

The management-based future scenario results predict a much narrower range of future conditions in the LCRB than in the UCRB populations, mostly because of the dominance of nonnative predators in the system. Management actions include collection of larvae and management of off channel ponds for growth and stocking throughout the system, neither of which are designed to improve resiliency but do actively manage redundancy and representation of the species. Nonnative predators are not managed in most LCRB habitats. Because of these constraints, only under scenario 5 is a return of demographic conditions to a high category

predicted in two populations. The most dramatic losses in resiliency in the lower basin are predicted in scenario 2 due to the reduced effectiveness of stocking, as stocking is the primary tool used to maintain populations on the landscape.

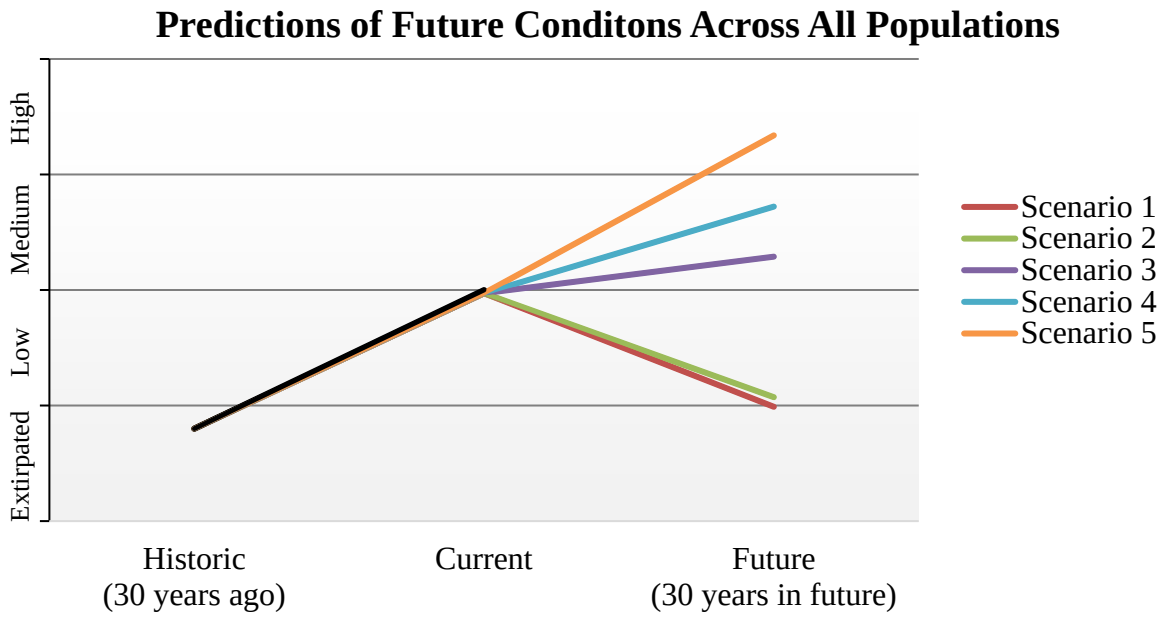


Figure EX3.Prediction of razorback sucker population response under the five future scenarios for all populations in relation to historic conditions at time of listing (~30 years ago).

When both basins are combined, predicted future condition ranges from high to low, with a larger distribution of values in the upper basin influencing the overall range (Figure EX3). The current condition of razorback sucker has been driven by the conservation actions that have occurred over the last 30 years, and it is likely that the population condition in the future will also be driven by those management actions. Should management actions continue and be successful, improvements are expected in resiliency. Should management actions cease, resiliency, and therefore redundancy and representation of razorback sucker are likely to decline.

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ACRONYMS AND ABBREVIATIONS

BO	Biological Opinion
CRI	Colorado River Inflow Area of Lake Mead
cfs	cubic feet per second
EIS	Environmental Impact Statement
ESA	Endangered Species Act
HCP	Habitat Conservation Plan
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LCRB	lower Colorado River basin
LGC	lower Grand Canyon
LM	Lake Mead
LTSP	Larval Trigger Study Plan
MCA	multicriteria analysis
mg/L	milligrams per liter
µS/L	microsiemens per liter
NDOW	Nevada Department of Wildlife
NPS	U.S. National Park Service
PBO	Programmatic Biological Opinion
PCR	Colorado River arm of Lake Powell
PIT	passive integrated transponder
PSJ	San Juan River arm of Lake Powell
Reclamation	U.S. Bureau of Reclamation
ROD	Record of Decision
SJRIP	San Juan River Basin Recovery Implementation Program
SL	standard length
SNARRC	Southwestern Native Aquatic Resources and Recovery Center
SSA	Species Status Assessment
TL	total length

UCRB	upper Colorado River basin
UCREFRP	Upper Colorado River Endangered Fish Recovery Program
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey

1 INTRODUCTION

1.1 Overview and Report Organization

This Species Status Assessment (SSA) report provides an assessment of the biological status of the federally endangered razorback sucker *Xyrauchen texanus*. Based on the best available scientific information, this SSA may be used by the U.S. Fish and Wildlife Service (USFWS) to inform Endangered Species Act (ESA)-related decisions about the species. The goal of the SSA is to provide a clear characterization of species viability, including controlling factors, species risks, and key uncertainties. This SSA does not replace or supplant species recovery plans or 5-year status reviews; it is intended to be a living document that is updated as new information about the status of razorback sucker is obtained (D. R. Smith *et al.* 2018).

This SSA is organized according to the following sections:

- 1.0 Introduction: provides an overview of the SSA framework and this document.
- 2.0 Species Overview: describes the species and taxonomy, listing status, range and distribution, and life history.
- 3.0 Species Needs: describes the resource needs of individuals and populations and aspects of the environment that are considered important to species viability.
- 4.0 Risk and Conservation factors: describes the risks and conservation measures likely to affect the species habitat and demographics.
- 5.0 Current Condition: describes current conditions of resources and species demographics by population.
- 6.0 Future Condition: describes the species' response to plausible future scenarios to provide the information necessary to assess future viability.

Throughout the assessment, the principles of resiliency, redundancy, and representation are used to ensure the SSA is biologically sound and that species conservation is fully considered (D. R. Smith *et al.* 2018):

- Resiliency describes the ability of a species to withstand stochasticity—either environmental or demographic. Resiliency can be measured by the abundance, survival and/or growth rate of a population, and may be influenced by connectivity amongst populations. Resiliency can be assessed at either an individual or a population level.
- Redundancy describes the ability of a species to withstand catastrophic events by spreading the risk among populations. Redundancy is characterized by having multiple, resilient populations distributed across the range of the species. It can be measured by the number of populations, their resiliency, and the spatial scale of their distribution and degree of connectivity.

- Representation describes the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Measures may include the number of varied niches occupied, genetic diversity, and heterozygosity, and/or alleles per locus. This principle involves the relationship between a species' life history and its genetic and ecological diversity, and the subsequent influence on the species' ability to adapt to changing environmental conditions.

1.2 Species Status Assessment (SSA) Framework

An SSA provides a consistent, conservation-focused, and scientifically sound assessment of the biological status of a species (D. R. Smith *et al.* 2018). The SSA entails the following assessment stages (Figure 1):

1. Species Needs: The first stage explores and describes the species' life history, including trophic niches, reproductive strategies, biological interactions and habitat requirements to determine how individuals at each stage survive and reproduce. The SSA identifies significant ecological, genetic or life history variation informed by historical as well as present distribution.

2. Species Current Condition: The second stage describes the current condition of the species' habitat, demographics and distribution and provides probable explanations for past and ongoing changes in abundance, distribution and diversity.

3. Species Future Condition: The last stage assesses the status of the species by projecting the species' response to probable future environmental condition scenarios. This stage describes a species' ability to sustain populations in the wild using a biologically meaningful period that considers generation time and longevity.

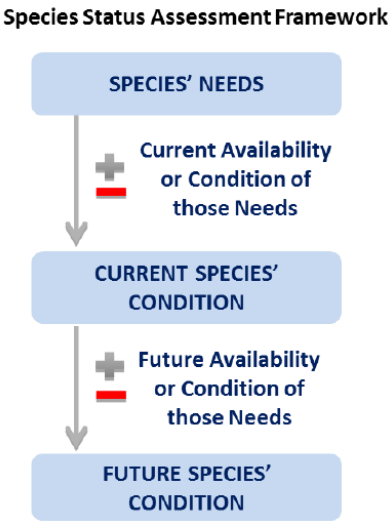


Figure 1. SSA Framework's three basic stages from the SSA Framework (U.S. Fish and Wildlife Service 2016).

Conducting an SSA involves compiling and analyzing the best available scientific information for the species. The SSA report is a stand-alone, science-based product independent of the application of policy or regulation. It provides foundational biological information, articulates key uncertainties, and ultimately characterizes the species' current and potential future condition and viability under various scenarios and timeframes (D. R. Smith *et al.* 2018).

1.3 Contributions from Experts

This SSA was developed in two phases with significant contributions from scientists and researchers who contribute to programs throughout the basins. During the first phase, 56 of 87 invited biologists participated in some part the Delphi process, which assessed the greatest threats to the viability of razorback sucker over multiple timeframes. Forty-seven biologists completed all surveys. During the second phase, a Science Team (made up of state and federal representatives from programs in both basins) qualified and categorized current condition and developed future scenarios based on the information provided in the Delphi process. The Science Team assessed the threats identified in the Delphi process and used best professional judgement to predict how those threats are likely to impact the species over a foreseeable future.

2 SPECIES OVERVIEW

2.1 Description and Taxonomy

Xyrauchen is one of several monotypic genera of the family Catostomidae. Razorback sucker was originally described as *Catostomus texanus* (Abbott 1861; Bestgen 1990; U.S. Fish and Wildlife Service 2002). Subsequent reclassifications were made by Kirsch (1889), who assigned it to the genus *Xyrauchen* due to the species' unique keel feature, and Jordan (1891), and later by Hubbs and Miller (1953), LaRivers (1962), and Minckley (1973). The species name *texanus* is based on a misunderstanding that the earliest specimens erroneously originated from the Colorado River in Texas (Marsh *et al.* 2015).

Meristic and morphological descriptions of the species, as cited in Bestgen (1990), follow below (Abbott 1861; Ellis 1914; Hubbs and Miller 1953; W. L. Minckley 1973; Moyle 1976; McAda and Wydoski 1980; Snyder and Muth 1990):

> The razorback sucker is distinguishable from all other catostomids by its unique, bony, dorsal keel abruptly rising posterior of the head. The body shape is elongate, robust, and somewhat laterally compressed. The caudal peduncle tends to be short and deep. An enlargement of the interneural bones forms the distinctive razor-like keel, providing basis for the common name, razorback sucker. The moderate-sized mouth has a clefted lower lip, and lateral margins of the lips are continuous and rounded. Razorback sucker have elongated heads with a flattened dorsal surface and well-developed fontanelle. There are usually 14–15 primary dorsal fin rays, seven primary anal fin rays, 45–47 vertebrae, 68–87 scales in the lateral series, with 44–50 gill rakers on the first arch. Body coloration is dark brown to olivacious on the upper dorso-lateral surfaces and ranges from yellow to white on the lower ventro-lateral surfaces. Adults can reach up to 1,000 mm total length (TL) and weigh 5–6 kg, but they are more typically found within the 400–700 mm TL range, weighing less than 3 kg. During spawning, razorback sucker are sexually dimorphic, with breeding males showing bright yellow and orange laterally and ventrally, dark dorsal surfaces, and tuberculation, especially on the anal and caudal fins, and females exhibiting a distended genital papillus.

Furthermore, based on skeletal measurements, razorback sucker morphology is heavily ossified, thickened, and likely adapted to the strong river currents historically occupied by this species (Eastman 1980).



Figure 2. Razorback sucker, photo provided by Melanie Fisher.

2.2 Listing Status and Recovery Planning

The razorback sucker was first proposed for listing as a threatened species on April 24, 1978 (43 FR 17375). The proposal to list as threatened was withdrawn on May 27, 1980 (45 FR 35410) to comply with provisions of the 1978 amendments to the ESA, which required the USFWS to include consideration of designating critical habitat in the listing of a species and to complete the listing process within 2 years after the date of a proposed rule or withdraw the proposal from further consideration. In this case, the USFWS did not complete the listing process within the 2-year deadline. On March 15, 1989, the USFWS received a petition to list the razorback sucker as endangered. Listing documents cited a lack of recruitment, dwindling numbers of adults, and occupation of only 25% of historical range as signs of endangerment and cited altered flow regimes, habitat dewatering, and negative interactions with nonnative fishes as factors affecting the species. The USFWS made a ruling in June 1989 to list the species as endangered and subsequently published a notice in the Federal Register on August 15, 1989. The proposed rule to list the species as endangered was published on May 22, 1990 (55 FR 21154). The final rule listing the razorback sucker as an endangered species was published on October 23, 1991 (56 FR 54957).

Subsequently, critical habitat was designated as 2,776 kilometers (km) of the Colorado River basin on March 21, 1994 (59 FR 13374). This was composed of 1,519 km in the upper Colorado River basin (UCRB or “upper basin”) and 1,255 km in the lower Colorado River basin (LCRB or “lower basin”) (Figure 3). The species was listed prior to the 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments (61 FR 4721-4725), and there are no

distinct population segments designated or proposed for the species (U.S. Fish and Wildlife Service 1998; U.S. Fish and Wildlife Service 2012).

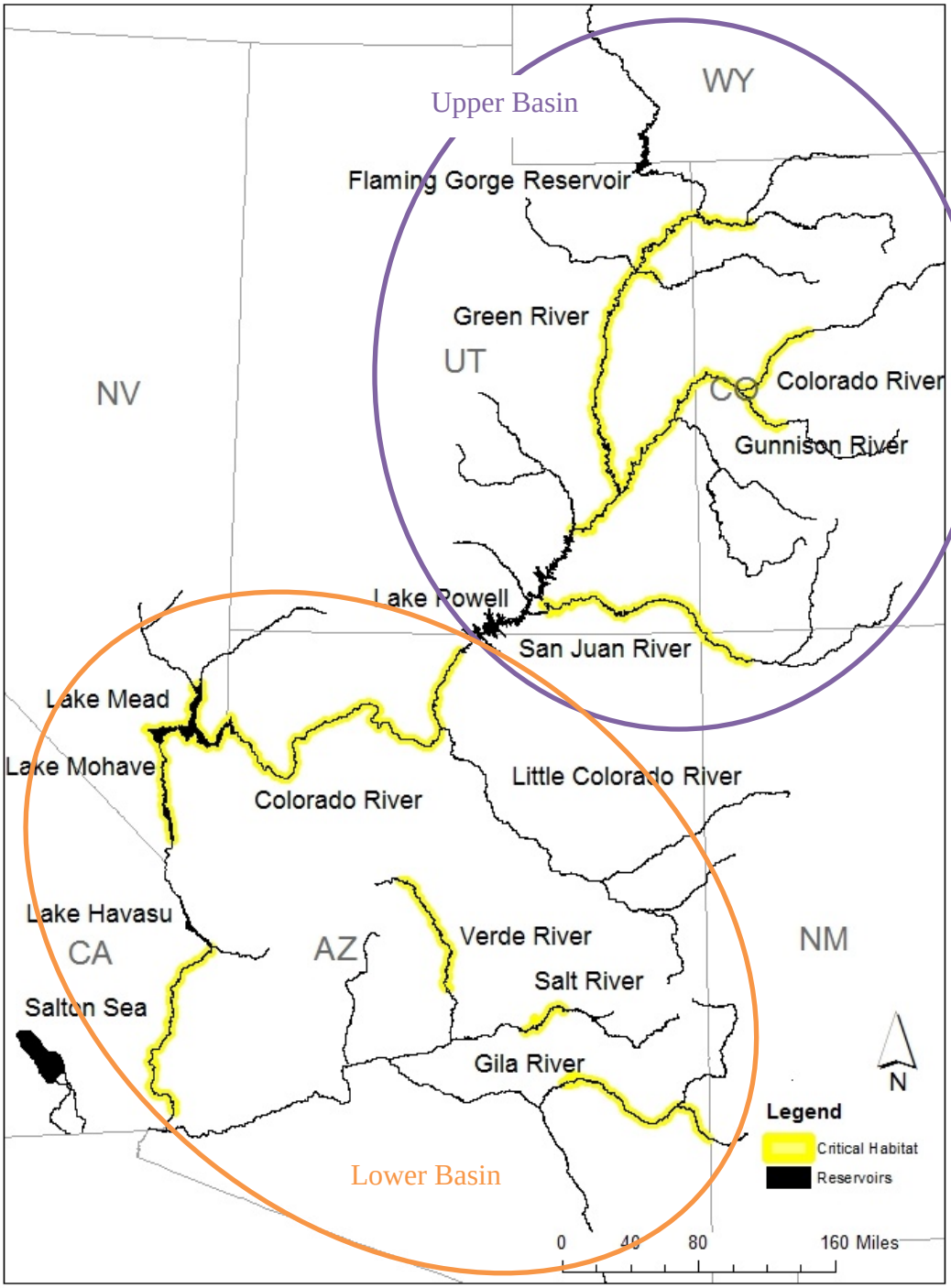


Figure 3. Critical habitat designated for the razorback sucker in 1994 (yellow highlight) and general areas defined as upper and lower basins.

The initial recovery plan for the razorback sucker was completed in 1998 (U.S. Fish and Wildlife Service 1998). Recovery goals that amended and supplemented the 1998 plan were approved

August 1, 2002 (U.S. Fish and Wildlife Service 2002). Downlisting criteria required genetically and demographically viable, self-sustaining razorback sucker populations in the Green River subbasin and either the Colorado River subbasin or the San Juan River subbasin, a genetic refuge in Lake Mohave, and two genetically and demographically viable, self-sustaining populations in the lower basin. Delisting required population improvements for three consecutive years post-downlisting. The last 5-year review for razorback sucker was completed in 2012 (U.S. Fish and Wildlife Service 2012). The 5-year review noted some improvements in demographic criteria, but most criteria had not been met; species status remained endangered. The threat removal criteria showed much greater improvements especially in relation to increased floodplain habitat and removal of fish passage blockages; implementation of flow recommendations and addition of fish screens were indicated as partially met (U.S. Fish and Wildlife Service 2012). The 5-year review indicated that the 2002 recovery goals needed to be updated with new information, especially in relation to the fact that populations are likely to fluctuate over time and not continue on an increasing trend in all years.

2.3 Historical Range and Distribution

Razorback sucker are endemic to the Colorado River Basin, which encompasses parts of seven western states including Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming as well as parts of Sonora and Baja California, Mexico. The upper and lower basins are split at Lees Ferry, Arizona, which is downstream from Glen Canyon Dam. Glen Canyon Dam, which was constructed in 1957-1964, provides physical separation between the UCRB and LCRB. Razorback sucker were widespread and common throughout the larger rivers of the entire basin (W. L. Minckley *et al.* 1991; Marsh 1996; Marsh 1996) (Figure 4) with particularly high razorback sucker abundance in the LCRB near Yuma, Arizona (Gilbert and Scofield 1898). Razorback sucker are thought to have been uncommon in turbulent, canyon-bound reaches, with robust populations typically being found in calm, flatwater river reaches (Tyus 1987; Lanigan and Tyus 1989; Bestgen 1990). Historical populations were affected by the construction of multiple in-stream impoundments in the early-to-mid 1900s, which changed riverine conditions. Razorback sucker has persisted in some resulting reservoirs but been extirpated in others.

2.3.1 Upper Colorado River Basin

Historically, razorback sucker were widespread in the UCRB in warm-water stream reaches (Bestgen 1990). By the time endangered fish studies began around 1980, populations were apparently reduced from historical levels (Bestgen 1990). The largest numbers of razorback sucker in the Upper Colorado River Basin were found in low gradient, flat-water reaches of the middle Green River between the Duchesne River and the Yampa River and in the Colorado River near Grand Junction (Tyus 1987; Bestgen 1990; Muth *et al.* 2000). In the upper Colorado River subbasin, the number of razorback sucker captured decreased dramatically after 1974. At that time the wild population was considered extirpated from the Gunnison River (Burdick and Bonar 1997) and there were only a few scattered adults in the mainstem Colorado River (D. B. Osmundson and Kaeding 1989b). Between 1984 and 1990, only 12 individuals were captured in the Colorado River in the Grand Valley (an area encompassing Grand Junction, Colorado) despite intensive collection efforts (D. B. Osmundson and Kaeding 1991). No young razorback sucker were captured anywhere in the upper Colorado River subbasin from the mid-1960s to

about 1990 (D. B. Osmundson and Kaeding 1991). The last wild razorback sucker in the UCRB was captured in the Colorado River in 1995.

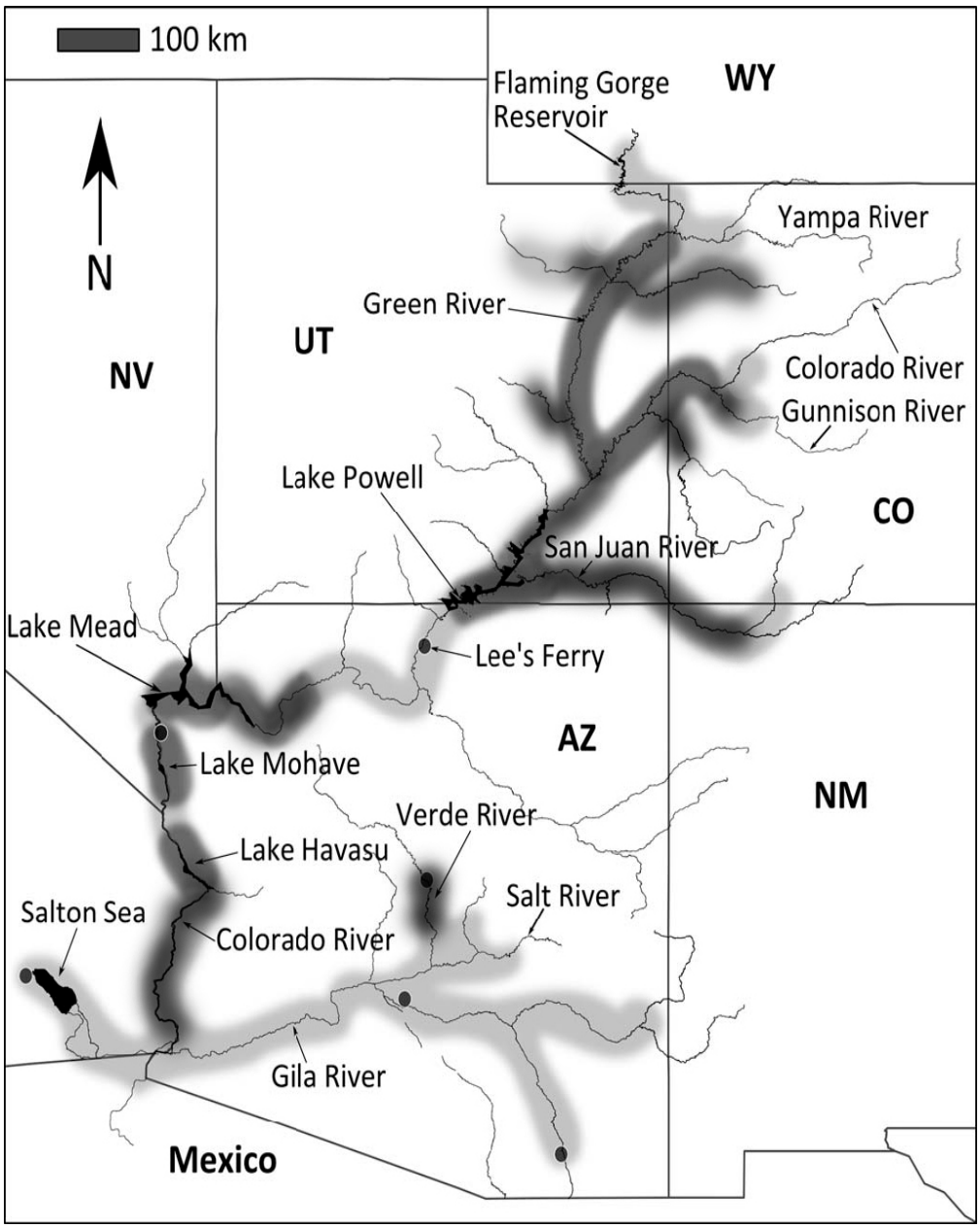


Figure 4. Historical (light gray highlights) and current (dark gray highlights) distribution of the razorback sucker in the Colorado River basin (points are archeological sites; dark gray portions of map were modified from Marsh *et al.* 2015). Reservoir and lake boundaries appear as solid black.

Bestgen *et al.* (2012) reported that wild razorback sucker were extirpated from the San Juan River subbasin, but that stocked hatchery-produced fish were surviving and reproducing annually. Anecdotal reports from the late 1800s document razorback sucker occurring in the Animas River as far upstream as Durango, Colorado (Jordan 1891), although there are no known

voucher specimens to confirm this observation. The first razorback sucker specimens were collected in the San Juan River in 1976, when two adults were collected in an irrigation pond near Bluff, Utah (VTN Consolidated, Inc., and Museum of Northern Arizona, 1978, as cited in (Farrington *et al.* 2015). No wild razorback sucker were found during the 7-year research period (1991–1997) of the San Juan River Basin Recovery Implementation Program (SJRIP) (Holden 1999).

Razorback sucker has recently been the subject of various investigations in Lake Powell. Little is known about historical status of rare fish in the Lake Powell as survey and monitoring results were limited (Bestgen 1990). Despite limited sampling, razorback sucker were known to have inhabited the San Juan River Arm of Lake Powell since 1982 (Francis *et al.* 2015).

2.3.2 Lower Colorado River Basin

The trend of declining razorback sucker populations observed in the Colorado River were also occurring in Lake Mead after Hoover Dam was completed in 1935. Razorback sucker numbers, initially high in Lake Mead, decreased noticeably in the 1970s, and no razorback sucker were collected during the 1980s (W. L. Minckley 1973; T. McCall 1980; W. L. Minckley *et al.* 1991; Sjoberg 1995). However, in the early 1990s, Nevada Department of Wildlife (NDOW) personnel confirmed razorback sucker was still present in two localized areas of Lake Mead: Las Vegas Bay and Echo Bay. Further explorations led to the discovery of several groups of wild fish spawning and recruiting in the reservoir. These groups currently represent the only known wild population of razorback sucker in the Colorado River basin to consistently demonstrate natural recruitment (Shattuck *et al.* 2011; Albrecht *et al.* 2013a; Albrecht *et al.* 2013b; Albrecht, Shattuck *et al.* 2014; Albrecht, Kegerries *et al.* 2014; Shattuck and Albrecht 2014; Kegerries, Albrecht *et al.* 2015; Mohn *et al.* 2015; Mohn *et al.* 2017).

Ten historical records exist for the presence of razorback sucker between Glen Canyon Dam and the upper extent of the inflows of Lake Mead between 1944 and 1990 (Valdez 1996; Valdez and Carothers 1998). Razorback sucker were detected in 1990 at the confluence of the Little Colorado River, but they were thought to be functionally extirpated in the Grand Canyon (Clarkson and Childs 2000). Limited information is available regarding the historical spawning activities of razorback sucker in the Grand Canyon (Albrecht *et al.* 2014), but presumptive razorback sucker larvae were found in the canyon in 1998 (M. R. Douglas and Douglas 2000). In 2012, the first adult razorback sucker was captured in Spencer Canyon in over 20 years (Bunch *et al.* 2012). Recently, both larvae and adult razorback sucker have been discovered utilizing both the lower Grand Canyon and the inflows to Lake Mead; razorback sucker have been documented to be spawning at least 161 river kilometers from Lake Mead consistently between 2014 and 2017. (Albrecht *et al.* 2014; Kegerries, Albrecht, Gilbert *et al.* 2017; Kegerries, Albrecht, Rogers *et al.* 2017).

The largest reservoir population of razorback sucker, estimated at 75,000 in the 1980s, occurred in Lake Mohave, Arizona and Nevada, but at present, no wild fish remain because of lack of recruitment (Marsh *et al.* 2003; Marsh *et al.* 2005; Marsh *et al.* 2015). However, Lake Mohave remains an actively managed and important genetic refuge for the species where larvae are collected, reared in the hatchery, and released back into the reservoir at larger sizes to improve

survival as little to no natural recruitment occurs as a result of predation (Marsh *et al.* 2003; Marsh *et al.* 2005; Dowling *et al.* 2014; Marsh *et al.* 2015). Frequent razorback sucker were also often reported in the riverine LCRB downstream of Lake Mohave from the early 1940s through early 1980s (W. L. Minckley 1983; Marsh and Minckley 1989).

The Gila River system encompasses the Verde, Gila and Salt rivers and their tributaries. Razorback sucker historically occupied all larger streams in the Gila River Basin including the Salt, Verde, and Gila Rivers (W. L. Minckley and Deacon 1968). By the 1970s, the species was extirpated from the basin and by 1981 efforts to reestablish razorback suckers had begun. Between 1981 and 1990, more than 11 million hatchery-produced razorback sucker were released at 57 sites into historic habitat in the Gila system where the natural population had been extirpated (Hendrickson 1994). Stockings during this period consisted of mostly fry and fingerlings, but were stocked at larger sizes (up to 300 mm) towards the end of that time period. Low short-term survival and no long-term survival was reported from these releases, primarily because of predation by nonnative fishes, including flathead catfish *Pylodictis olivaris*. In 1991, razorback sucker were stocked at lengths >300 mm to reduce predation. From 1991 through 2003, 24,915 larger sized razorback suckers were stocked into two locations on the Verde River and a single stocking of 2,046 fish were stocked in 1996 in the Salt River. Numerous fish were recaptured (283 in the Verde River and 2 in the Salt River) and survival up to six years was documented (Hyatt 2004). However, limited post stocking monitoring (once per year) did not allow for adequate assessment of survival. In addition, ripe males were encountered in the Verde River, but no evidence of reproduction or recruitment was found (Hyatt 2004). Because of a lack of recaptures, which indicates low adult survival despite stocking efforts, the Verde River will not be assessed in this report as a population.

In summary, razorback sucker adults are present and spawning across much of the Colorado River basin but some areas have patchy distributions. Species presence is likely due to the species' ability to utilize both lotic (rapidly moving fresh water like a river) and lentic (still, fresh water like a reservoir or lake) environments. Four populations, all maintained by stocking, are currently present in the UCRB, including in the Green, Colorado and San Juan subbasins and Lake Powell. LCRB populations currently occur in Lake Mead (and the Colorado River upstream of Lake Mead), Lake Mohave, the Colorado River between Davis and Parker dams (Lake Havasu), and the Colorado River below Parker dam, and all except the first are maintained by stocking. Although other, smaller, isolated, and more localized sources of razorback sucker can be found in various ponds, backwaters, and other habitat types common to the LCRB, they are not included herein as not all are sampled routinely or with the specific purpose to produce abundance estimates.

2.4 Life History

Razorback sucker is one of the better-studied species of Colorado River fishes, and its life history has been described by numerous researchers (Bestgen 1990; W. L. Minckley *et al.* 1991; U.S. Fish and Wildlife Service 1998; U.S. Fish and Wildlife Service 2002; Stymeist 2005; Valdez *et al.* 2011; Marsh *et al.* 2015).

Conceptual models are useful to diagram life stages and help elucidate biotic and abiotic factors that control life stages of a species (D. R. Smith *et al.* 2018). Razorback sucker life history can be divided into five life stages eggs, larvae, juveniles, adults and spawning adults. The basic needs of each life stage are described below and summarized at the end of this section (Table 1).

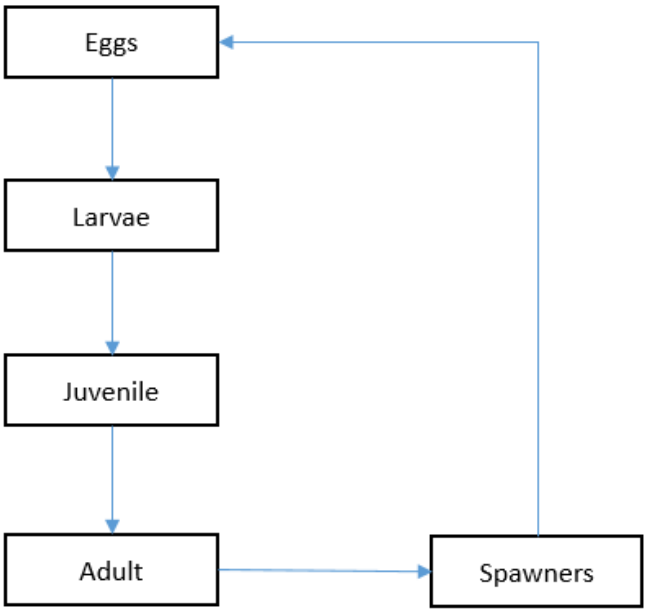


Figure 5. Simplified razorback sucker life stage model adapted from Valdez *et al.* 2011, which will be used to show relationships between species needs, risks and conservation actions through the SSA.

2.4.1 Feeding

Razorback sucker diet is dependent on life stage, habitat, and food availability. Razorback sucker larvae have terminal mouths and shortened gut lengths, which appear to facilitate and necessitate selection of a wide variety of food types. Transition from nourishment by the yolk to exogenous feeding by mouth occurs at approximately 10 mm TL (approximately 8–19 days post-hatch), after which larvae from lentic systems feed mainly on phytoplankton and small zooplankton, while lotic-inhabiting larvae are assumed to feed largely on chironomids and other benthic insects (W. L. Minckley and Gustafson 1982; Marsh and Langhorst 1988; Bestgen 1990; Papoulias and Minckley 1990; U.S. Fish and Wildlife Service 1998). In hatchery studies, larval razorback sucker survival is enhanced when food levels are within the range of 50–1,000 organisms/liter (Papoulias and Minckley 1990). As razorback sucker grow, they undergo an ontogenetic shift in mouth morphology, with the mouth becoming more inferior, allowing juveniles more efficient access to benthic food sources (U.S. Fish and Wildlife Service 1998).

As adults, razorback sucker display differing diet compositions, depending on whether the individual exists in a lotic or lentic setting (Bestgen 1990; U.S. Fish and Wildlife Service 1998). Lotic adult razorback sucker consume a mixture of benthic invertebrates, algae, detritus, and inorganic materials, but there is little evidence of zooplankton consumption in rivers (Jonez and Sumner 1954; Banks 1964; Vanicek 1967). Lentic-inhabiting adult razorback sucker diets are dominated by cladoceran zooplankton; some algal and detrital materials are also present in gut contents (W. L. Minckley 1973; Marsh 1987).

2.4.2 Breeding

Razorback sucker take 2-6 years to reach maturity, depending on rearing habitat, which equates to 350 to 450 mm TL or greater (Bestgen 1990; Albrecht *et al.* 2009). Fecundity for razorback sucker, expressed in terms of number of ova per unit standard length (ova/SL) ranges from 1,600 ova/cm SL to 2,000 ova/cm SL (W. L. Minckley 1983). During the spawning season in LCRB reservoirs, male/female ratios of captured razorback sucker range from 1.2–3.6: 1 (Bozek *et al.* 1984; Albrecht *et al.* 2014) and were documented at 2.5:1 in the Green River (Bestgen 1990).

Razorback sucker's spawning season varies latitudinally, and thus between basins. In UCRB riverine habitats, ripe razorback sucker have been collected from mid-April to mid-June (4–5 weeks) when temperatures reach 14-16°C and springtime flows peak (Tyus 1987; D. B. Osmundson and Kaeding 1989a; D. B. Osmundson and Kaeding 1989b; Bestgen 1990; Tyus and Karp 1990a; Tyus and Karp 1990b). In lotic environments where higher spring flows connect backwater and floodplain habitats, adult razorback sucker have been documented moving into these areas that are typically 2–-4°C warmer than main channel environments. This behavior is called "staging," and it presumably allows additional thermal units to be obtained, which is thought to stimulate gamete production and minimize the costly act of spawning (Tyus and Karp 1990a; U.S. Fish and Wildlife Service 1998; Holden 1999; Ryden 2000). In the UCRB, spawning razorback sucker use substrate consisting largely of cobble, located in water velocities of approximately 1.0 m/s and depths of 1 m (McAda and Wydoski 1980). Spawning and egg deposition occurs in flooded lowlands and in eddies formed at river confluences or on main-channel gravel and cobble bars (McAda 1977; McAda and Wydoski 1980; Tyus 1987; Tyus and Karp 1990a; Modde and Irving 1998). Spawning in riverine sections has also been associated with increasing spring flows and associated turbidity (Tyus 1987; Tyus and Karp 1990a; Modde *et al.* 2005). Spawning razorback sucker have also been found in Lake Powell over talus (Francis *et al.* 2015).

In lentic LCRB habitats, the majority of spawning generally occurs between January and April when water temperatures are typically 10–20 °C or higher (Albrecht *et al.* 2008; BIO-WEST unpublished data). Spawning populations have been located in Lake Mead (Jonez and Sumner 1954; Holden *et al.* 1997; Holden *et al.* 1999; Holden *et al.* 2000a; Holden *et al.* 2000b; Holden *et al.* 2001; Abate *et al.* 2002; Welker and Holden 2003; Albrecht, Sanderson *et al.* 2008; Albrecht, Holden *et al.* 2010; Albrecht *et al.* 2013a; Kegerries *et al.* 2015; Mohn *et al.* 2015), Lake Mohave (Bozek *et al.* 1984; Marsh and Langhorst 1988; Mueller 1989; Bozek *et al.* 1990; Marsh *et al.* 2015), Lake Havasu (P. A. Douglas 1952; W. L. Minckley 1983; R. Wydoski and Mueller 2006) and Senator Wash Reservoir (Medel-Ulmer 1980; Kretschmann and Leslie 2006). Spawning activities are most frequently associated with relatively shallow, flat to gently sloping shoreline areas over relatively clean gravel and cobble (Bestgen 1990). Spawning activity has been documented in depths of up to 20 m in Lake Mead, but it typically occurs in less than 2 m of water (W. L. Minckley *et al.* 1991; Holden *et al.* 1997; Holden *et al.* 1999). Spawning fish often congregate near river inflow areas, which are usually more turbid than most available habitats (Jonez and Sumner 1954; Holden *et al.* 1997; Holden *et al.* 1999; Albrecht *et al.* 2010; Albrecht *et al.* 2014; Kegerries *et al.* 2015).

Razorback sucker display strong spawning site fidelity, both in lentic and lotic habitats (Mueller 1989; Tyus 1990; Holden *et al.* 2000a; Holden *et al.* 2000b; Holden *et al.* 2001; Abate *et al.* 2002; Welker and Holden 2003; Welker and Holden 2004; Modde *et al.* 2005).

2.4.3 Survival and Growth

Successful razorback sucker egg incubation occurs above 8°C, primarily from 9.5 to 20°C (W. L. Minckley and Gustafson 1982; Bozek *et al.* 1990). Egg mortality has been attributed to fluctuating water levels, current scouring and/or wave action, suffocation due to silt deposition, and nonnative predation (W. L. Minckley 1983; Bozek *et al.* 1984). Additionally, dissolved oxygen concentrations below 2.5 milligrams per liter (mg/L) and high salinity (11,000–12,000 microsiemens per liter [µS/L]) are fatal to egg incubation (Stolberg 2012a; Stolberg 2012b). In laboratory experiments, the majority of larval mortality likely occurs within 20–30 days of hatching and is a result of starvation, indicating that zooplankton levels are an important driver of larval razorback sucker survival (Papoulias and Minckley 1990).

Published growth estimates for razorback sucker vary and available information is highly dependent on life stage, habitat type, and overall ecological setting (e.g., temperature, food availability; see reviews by Bestgen 1990 and U.S. Fish and Wildlife Service 1998). Most growth information for larval and juvenile razorback sucker has been based on hatchery-produced fish (Marsh 1985; Brooks 1986; Marsh and Brooks 1989; W. L. Minckley *et al.* 1991; Mueller 1995). Razorback sucker that are 7–9 mm at hatch can reach lengths of more than 23 mm TL within 2 months (Papoulias and Minckley 1990). Fish growth is dependent on both water temperature and the quality and quantity of food available; water temperatures above 25 C dramatically decreased the time required to reach 25 mm, which is thought to be a threshold to reduce predation (Bestgen 2008). Subsequently, during the initial 6 years of life, razorback sucker appear to grow rapidly (e.g., growth of 55–307 mm TL in 6 months for young razorback sucker stocked into ponds) (D. B. Osmundson and Kaeding 1989a), after which growth is minimal (2.0 mm TL/year or less) (McCarthy and Minckley 1987; W. L. Minckley *et al.* 1991; Modde *et al.* 1996).

Snyder *et al.* (2004) describe the transition from larvae to juvenile as beginning at 27–30 mm TL and ending at 32–35 mm TL. The juvenile razorback sucker life stage ranges from 27–450 mm TL depending on capture location and fish origin. Generally, fish in the UCRB greater than 350 mm TL are sexually mature (Muth *et al.* 2000).

2.4.4 Dispersal

Dispersal of razorback sucker larvae from spawning bars in rivers occurs during high spring runoff flows. These small, drifting larvae are more likely to survive if they drift into floodplain wetlands, which are food-rich and protected from predators (Muth *et al.* 2000). Success can depend on the magnitude and duration of spring discharge, proximity to and interaction with floodplains, water temperature and variability, geomorphic factors, and turbidity. The relationship between river flow and floodplain connection is important to drifting larvae; it ensures that larvae become entrained in food-rich habitats (Bestgen *et al.* 2011; LaGory *et al.* 2012). Movement of juveniles has been studied in reservoirs, finding movements of up to 7 km

per day (Mueller and Marsh 1998). Dispersal movements are also common until adequate habitat is found, which varies between shallower habitats with cover during most of the year and retreat to deeper waters during warm summers (Kegerries, Shattuck *et al.* 2015; Kegerries, Albrecht, Mohn *et al.* 2017).

Provided there are no artificial barriers, adult razorback sucker can move long distances throughout the river systems including between subbasins, though most do not (STReaMS 2016). Three fish stocked into the San Juan River in 2004 and 2006 were captured in 2008 near the Colorado-Utah state line on the Colorado River, each having moved over 550 km. Another razorback sucker stocked into the San Juan River in 2010 was captured in the Green River in 2011 at river-km 159, also traveling more than 550 km (Durst and Francis 2016). These movements may be related to spawning, but do indicate that long-distance movements are possible.

2.4.5 Habitat

It appears that razorback sucker use available habitat, regardless of location. Historically, razorback sucker inhabited virtually all components of low velocity riverine habitat; backwaters, floodplains, sloughs, oxbow lakes, and other slackwater habitats within the main channel were particularly important (Holden 1973; Holden and Stalnaker 1975; Behnke and Benson 1983; W. L. Minckley 1983). Reaches in the UCRB tend to consist of higher-gradient, erosional, dynamic sections, whereas LCRB riverine habitats are more depositional, channelized, homogenous habitat types occasionally interspersed with highly vegetated, perennial, and permanently connected man-made off-channel backwater and floodplain impoundment structures (Bradford and Gurtin 2000). Seasonally submerged off-river habitats including bottomlands and other marsh-like, lowland habitats likely were important habitat for razorback sucker prior to the construction of mainstream dams (Tyus and Karp 1989; Bestgen 1990; D. B. Osmundson 2001). The razorback sucker is also known to complete its entire life cycle within lentic habitat types (Albrecht *et al.* 2010) and likely did so historically within the off-channel, backwater, and floodplain habitats described above. This information lends additional insight into the overall plasticity of razorback sucker, assuming certain levels of habitat complexity, cover, and predation/competition levels are available (Albrecht *et al.* 2010).

In lotic settings, larval razorback sucker are often associated with backwater and in-channel slackwater-type habitats with low velocities (Tyus 1987; Muth *et al.* 1998). However, construction of mainstem dams, coupled with channelization and detrimental competition from and predatory effects of nonnative fishes, has likely contributed to elimination of important nursery areas. Many nursery habitats have been cut off or presently serve as strongholds for nonnative fishes that prey on and compete with young razorback sucker (Tyus and Karp 1990a; D. B. Osmundson and Kaeding 1991; W. L. Minckley *et al.* 1991; Mueller 1995; Tyus and Saunders 1996; Modde *et al.* 2005).

Habitat preferences for juvenile razorback sucker remain relatively understudied, as captures of this size class have been minimal in recent years (Tyus 1987; Bestgen 1990; U.S. Fish and Wildlife Service 1998; Albrecht *et al.* 2009; Shattuck *et al.* 2011). Historical data indicate large assemblages of juveniles in river margins warmer than the river itself (Sigler and Miller 1963).

Telemetry data demonstrated that juvenile razorback sucker utilized backwaters, vegetated areas, and rocky cavities thought to provide important cover and food resources (Mueller and Marsh 1998). Additionally, warmer (18–26.6°C) backwater-type habitats presumably allow for rapid growth during this life stage (Modde *et al.* 2001; Snyder *et al.* 2004). This description of habitat use is corroborated by the recapture of two experimentally stocked juvenile razorback sucker in the San Juan River (Holden 1999). These fish occupied slackwater and backwater pools that were 0.3–0.9 m deep and 1–3°C warmer than adjacent main-channel habitats. Juvenile razorback sucker also inhabit floodplain depressions (depth = 1.0–2.0 m, dissolved oxygen greater than 2.0 mg/L [usually above 5.0 mg/L], and maximum surface temperatures of 26.6 °C) because of habitat variables such as zooplankton density, water temperature, depth, and vegetative cover abundance (Modde 1996; Modde 1997; Modde *et al.* 2001; Modde and Haines 2005). Growth and survival are greater in floodplain depressions than main-channel habitats, and can provide a refuge from nonnative predation when actively managed (Schelly and Breen 2015).

Lake Mead razorback sucker studies document the capture of wild juvenile (sexually immature) razorback sucker, mainly collected along shallow shoreline habitats, near turbid inflow areas, and proximal to submerged vegetation, suggesting that densely covered, complex habitat types may provide an escape from nonnative predation (Holden *et al.* 1997; Holden *et al.* 1999; Holden *et al.* 2000a; Holden *et al.* 2000b; Holden *et al.* 2001; Abate *et al.* 2002; Welker and Holden 2003; Welker and Holden 2004). Telemetry efforts depict the generally cryptic nature of this life stage as evidenced by minuscule movement patterns, heavy utilization of cover types (including both vegetation and turbidity), possible nocturnal movement patterns during some seasons, and an affinity for marginal habitats that were relatively devoid of nonnative fishes within complex Lake Mead inflow habitats (Albrecht *et al.* 2013b; Shattuck and Albrecht 2014; Kegerries *et al.* 2015; Kegerries *et al.* 2017).

In lotic systems, adult razorback sucker use pools and slow eddies from November through April (Ryden 2000). As flows rise in the spring, razorback sucker associate with eddies along the inside of large river bends; displaying a strong affinity for mid-channel cobble riffles and run/riffles, as well as shoreline cobble-shoal-run type habitats (Ryden 2000). Adult fish increased their use of backwater habitats during May and June (D. B. Osmundson and Kaeding 1989a) and shift to higher velocity waters associated with submerged mid-channel sandbars in the summer (Tyus 1987; Ryden 2000). Few adult razorback sucker utilize swift, whitewater habitats (like Blackrocks and Westwater canyons in the UCRB), although movement of fish through these locations has been documented (Tyus and Karp 1990a; Albrecht *et al.* 2014; Kegerries *et al.* 2015).

In lentic systems, studies adult razorback sucker use a wide variety of habitats, including inundated vegetation, shorelines, and substrates ranging from silt and sand to gravel and cobble (Albrecht *et al.* 2008a). Adult razorback sucker occupy depths less than 30 m, generally located within 100 m of the shore during the winter, and less than 30 m from shore during peak spawning; however, during the summer, adults were located at depths often surpassing 30 m, (Marsh and Minckley 1989; Holden *et al.* 1997; Holden *et al.* 1999; Mueller *et al.* 2000; Holden *et al.* 2000a; Holden *et al.* 2000b; Holden *et al.* 2001; Abate *et al.* 2002; Welker and Holden 2003; Welker and Holden 2004; Albrecht, Kegerries *et al.* 2008; Albrecht *et al.* 2010; Albrecht *et al.* 2014; Kegerries *et al.* 2015). Adult razorback sucker are found in reservoir inflow areas

where the presence of turbidity may be important for all life stages of razorback sucker to avoid predation from nonnative species (Albrecht *et al.* 2017). Turbidities greater than 500 NTU may reduce sight feeder predation on juvenile razorback sucker by 50% (B. Vaage, D. Ward, and R. Morton-Starner, U.S. Geological Survey, unpublished data). Typically, inflow areas will show higher turbidity than reservoir basins year-round. Substrate complexity that can be used for spawning and feeding is often found within these inflow areas. Furthermore, large wood and vegetation transported from the river channel provides unique, much needed structure at each of these zones (Albrecht *et al.* 2017).

Table 1. Selected information describing observed conditions for razorback sucker by life stage and references.

Life Stage	Resource Information	References
Fertilized Eggs	Clean rocky substrates for adhesive eggs for 3–4 hours post fertilization. Gravel and cobble, at near shore locations, and typically at depths of <4.9 m, but have been noted to spawn over clay/dirt beds	Sigler and Miller 1963; Minckley and Gustafson 1982, Minckley 1983; Bozek *et al.* 1984; Marsh and Langhorst 1988; Holden *et al.* 1997, 1999, 2000a, 2000b, 2001; Abate *et al.* 2002; Welker and Holden 2003, 2004; Albrecht *et al.* 2008, 2010, 2014; Kegerries *et al.* 2015a
	Survive in water temperature 9.5–20 °C, at 15.0° C eggs hatch in 5.2–11.4 days	Minckley and Gustafson 1982, Bozek et al. 1984
	Successful hatch reduced <= 10°C	Bozek *et al.* 1984
	Dissolved oxygen >2.5 mg/L	Stolberg 2012a
	Salinities between 1,000–3,000 µS/cm were most successful but can tolerate upwards of 12,000 µS/cm. Eggs display greater sensitivity to salinity than larvae	Stolberg 2012b
Larvae (9–27 mm TL)	Diet rich with invertebrates increases growth, 50–1,000 invertebrates/L for minimal mortality	Snyder *et al.* 2004; Papoulias and Minckley 1992; Papoulias and Minckley 1990
	Lotic **-** Backwater, floodplain, and in-channel slackwater habitats and flows sufficient to move larvae into these habitats.	Tyus 1987; Muth *et al.*1998; Bestgen *et al.* 2011
	Lotic **-** Chironomids and other benthic insects	Minckley and Gustafson 1982; Marsh and Langhorst 1988
	Lentic - Phytoplankton and small zooplankton	Minckley and Gustafson 1982; Marsh and Langhorst 1988; Papoulias and Minckley 1990
	10–26.6 °C with 18–20 °C being typical	Modde *et al.* 2001; Snyder *et al.* 2004
	Dissolved oxygen >2.5 mg/L	Stolberg 2012a
	Can survive in salinities as high as 23,000–27,750 µS/cm	Stolberg 2012b

Juvenile 27 to <450 mm TL and sexually immature	Benthic-associated food items	U.S. Fish and Wildlife Service 1998; Snyder *et al.* 2004; Albrecht *et al.* 2009; Shattuck *et al.* 2011
	Lotic	
	Backwaters, floodplains , vegetated areas, rocky substrates, and flows sufficient to maintain healthy conditions	Mueller and Marsh 1998; Mueller 2006; Bestgen *et al.* 2011
	Dissolved oxygen >2.0 mg/L, usually > 5.0 mg/L, and maximum temperatures 26.6 °C	Modde 1996 and Modde *et al.* 2001
	Lentic	
	22.9–26.6 °C	Bulkley and Pimentel 1983; Modde 1996; Modde *et al.* 2001
	Shallow shoreline habitats, near turbid inflow areas and submerged vegetation	Holden *et al.* 1997, 1999, 2000a, 2000b, 2001; Abate *et al.* 2002; Welker and Holden 2003, 2004
	Cover types including vegetation and turbidity, possible nocturnal movement patterns during some seasons, and the affinity to utilize marginal habitats that are mostly devoid of nonnative fishes within inflow habitats	Albrecht *et al.* 2013; Shattuck *et al.* 2014; Kegerries *et al.* 2015a
Adult (sexually mature)	***Lotic***	
	Mixture of benthic invertebrates, algae, detritus, and inorganic materials	Banks 1964; Vanicek 1967
	Lentic	
	Midge (chironomid) larvae, cladoceran zooplankton, with some degree of algal and detrital material	Jonez and Sumner 1954; Minckley 1973; Marsh 1987
	Lotic	
	Inhabited virtually all components of riverine habitat, including low-velocity habitats such as backwaters, floodplains, sloughs, oxbow lakes, and other slackwater habitats within the main channel	Holden 1973; Holden and Stalnaker 1975; Behnke and Benson 1980; Minckley 1983; Mueller 2006
	Winter	
	Pools and slow eddies from November through April	Osmundson and Kaeding 1989a
	Notably sedentary main channel runs, eddies, and shore runs that averaged 1.1 m deep with velocities of 0.3 m/s were selected habitats	Ryden 2000

During prerunoff periods (March and April), fish used a variety of low-velocity habitats, such as slackwaters, pools, sand-shoals, flooded near-shore areas and submerged, off-river habitats including bottomlands and other marsh-like, lowland habitats.	Ryden 2000; Tyus and Karp 1990; Tyus 1987; Tyus and Karp 1989; Osmundson 2001; Bestgen 1990
Summer	
Subsequently shifted habitat use to shallow waters associated with submerged mid-channel sandbars	Tyus 1987
Backwater habitat use May and June	Osmundson and Kaeding 1989a
Shifting to runs and pools from July through October	Osmundson and Kaeding 1989a
Inundated vegetation	Ryden 2000
Mean depth was 1.2 m, velocity 0.7 m/s and mean temperature=21.1 °C	Ryden 2000
Autumn	
Shift from slow to fast main channel habitats with depths of 1.2–1.9 m, temperature=5.3 °C and velocity= 0.4 m/s	Ryden 2000
Lentic	
Wide variety of habitats: pelagic, vegetated areas, littoral shoreline	Minckley *et al.* 1991; Albrecht *et al.* 2008; Marsh *et al.* 2015, and numerous others
Substrates: silt and sand, to gravel and cobble	Minckley *et al.* 1991; Albrecht *et al.* 2008; Marsh *et al.* 2015, and numerous others
<30 m deep (averaging between 3.1–16.8 m), within 100 m from the shore during winter months (less than 30 m from shore during peak spawning activity)	Marsh and Minckley 1989; Holden *et al.* 1997, 1999, 2000a, 2000b, 2001; Mueller *et al.* 2000; Abate *et al.* 2002; Welker and Holden 2003, 2004; Albrecht *et al.* 2008; Albrecht *et al.* 2010a; Albrecht *et al.* 2014; Kegerries *et al.* 2015a
Summer months, adults were located at deeper depths, often > 30 m	
Thermal preference lies within the range of 22–25 °C based on laboratory observations and lethal temperature of 30–41 °C	Bulkley and Pimentel 1983

Spawners	***Lotic***	
	Spawning associated with the ascending limb of hydrograph	Ryden 2000
	Cobble-bottomed riffles or substrates consisting of scoured sands and gravels. Mean depths of 1-2 m with velocity of 0-0.4 m/s and mean temperature of 14.8 °C	Ryden 2000, Mueller 1989
	Lentic	
	10 °C to more than 20 °C	Bestgen 1990; Albrecht *et al.* 2008; unpublished BIO-WEST data
	2–20 m deep	Holden *et al.* 1997, 1999; Minckley *et al.* 1991
	Primarily clean, gravel- and cobble-sized substrates, but other substrate types have been documented	Douglas 1952; Bozek *et al.* 1990; Minckley *et al.* 1991; Tyus 1987; Tyus and Karp 1990
	Near river inflow areas with more turbid areas and stands of inundated vegetation	; Holden *et al.* 1997, 1999; Albrecht *et al.* 2010a; Albrecht *et al.* 2014; Kegerries *et al.* 2015a

3 SPECIES NEEDS

Some needs of razorback sucker are specific to a single life stage, while others apply to multiple life stages, populations or the species as a whole. These needs, which are described in more detail in the section above (Table 1, above), can be summarized as eight fundamental categories. We note that not all needs are limiting factors for each respective level, and although they may be present in the abiotic environment, access to these required needs may be restricted due to stressors and risks summarized in Chapter 4 of this document. For example, the impacts of aquatic nonnative species that compete with, or prey on, razorback sucker may interact with each of these parameters and therefore limit access to the resources even if they are present. Species needs describe our current understanding of the species. More information may lead to alternative conclusions as scientific studies become more robust or more is known about historic conditions.

3.1 Complex lotic and/or lentic habitat (*Individual need*)

Depending on life stage and location, the razorback sucker uses the suite of available habitats in reservoirs, main channels, backwaters, and floodplain wetlands. Three specific habitat types are thought to be necessary to complete the life cycle. First, razorback sucker use rocky substrates of boulder, cobble, and clean gravel usually along river margins, mid-channel bars, and island complexes, or reservoir, floodplain, and backwater shorelines for spawning adults and subsequent egg development. Second, larvae and juveniles need access to persistent, shallow, and warm, sheltered shorelines of backwaters, floodplains, or similar habitat types with cover present (vegetation and/or turbidity) to avoid predation. Inflow areas provide some of the best spawning and juvenile habitat similar to historic backwaters, floodplain wetlands, and other features. High cover in the form of turbidity and/or emergent or submerged vegetation likely provides protection from predation and allows for greater survival of small fish (R. S. Wydoski and Wick 1998; Mueller 2006; Albrecht *et al.* 2014; Kegerries *et al.* 2015). Third, adults need pockets of deeper water, either in reservoirs, large eddies or pools with slow velocities.

3.2 Suitable water temperature and quality (*Individual need*)

The razorback sucker is a warm water adapted species. Temperature preference of adult razorback sucker was estimated at 22–25 °C, based on laboratory observations (Bulkley and Pimentel 1983). This species was historically known for its migrations to spawning locations, and today this same attribute likely benefits the species by allowing adults to find appropriate thermal regimes, whether in the lotic, lentic or some combination of the two environments (W. L. Minckley *et al.* 1991; Valdez *et al.* 2011; Valdez *et al.* 2011). Larvae have been captured in water ranging from 10.0 to 26.6 °C, but they are more frequently collected in 18.0–20.0 °C water (Marsh 1987; Modde *et al.* 2001; Modde *et al.* 2001; Snyder *et al.* 2004; Snyder *et al.* 2004). Razorback sucker are tolerant of a wide range of water quality conditions, including pH ranges between 6.0 and 9.0 (Slaughter *et al.* 2002), dissolved oxygen levels as low as 2.0 mg/L (Modde 1996; Modde *et al.* 2001; Modde *et al.* 2001; Stolberg 2012a; Stolberg 2012a) and salinities of up to 23,000–27,750 µS/cm (Stolberg 2012b). While razorback sucker are adapted to a variety of water quality conditions, the need for water quality conditions within these ranges remains.

Tolerance levels to other water quality contaminants remain unknown, including the effects of metals or endocrine disrupting chemicals.

3.3 Variable Flow Regimes (*Individual need*)

Specific flow regimes have not been well identified for razorback sucker, but adults are often found in riverine habitats where the current velocity is near 0.5 m/sec (Ryden 2000). More than likely, the species benefits from variable flows mimicking natural pre-dam conditions that maintain channel diversity, stimulate food production, and disadvantage nonnative predators and competitors (Muth *et al.* 2000). As evidenced in the UCRB, in lotic settings, the species spawns on the ascending limb of spring runoff, and typically spawns on rocky shorelines and mid-channel cobble-gravel bars that are generally available over a range of flows (Muth *et al.* 2000). Flows sufficient to entrain larval razorback sucker into backwaters, floodplain wetlands, and other similar habitat types are considered essential for this species in these environments (Bestgen *et al.* 2011; LaGory *et al.* 2012). Inter-annual variability in peak flows drives connections to many of these floodplain environments. In lentic settings, reservoir elevation patterns have been considered important for reproduction, egg, and larval survival (W. L. Minckley *et al.* 1991; Albrecht *et al.* 2010). In these lentic systems, the presence of sufficient flow/water availability is more essential than the variation in that flow. Variable flow regimes are applicable only to lotic populations.

3.4 Food supply (*Individual need*)

Sufficient food is required to maintain growth and health of razorback sucker. The razorback sucker has an omnivorous diet that appears to shift by life stage. Diet composition is highly dependent on habitat and food availability. Larval razorback sucker survival is maximized when food levels are within the range of 50–1,000 organisms/liter (Papoulias and Minckley 1990). During later growth, razorback sucker undergo an ontogenetic shift in mouth morphology, thereafter, razorback sucker, while continuing to be opportunistic feeders, likely consume a variety of food items (U.S. Fish and Wildlife Service 1998).

3.5 Range and Connectivity (*Species need)*

Range and connectivity are important to razorback sucker, as the species was historically migratory, particularly during spawning (W. L. Minckley *et al.* 1991). The ability to move within and among systems supports populations through access to appropriate habitat and genetic exchange. Migrations of this species can be limited by large dams or unmodified diversions, and the presence of large-bodied nonnative predators but the species has nevertheless been observed navigating hundreds of miles within both reservoir and riverine environments (Durst and Francis 2016).

3.6 Population size and numbers (*Population need - Resiliency*)

Resilient populations have demographic ability to absorb and bounce back from disturbance and persist at the population or meta-population scale (D. R. Smith *et al.* 2018). To do that, abundance of individuals must be sufficient to maintain a healthy population and the organism

must be able to complete all life stages to ensure biological succession. Razorback sucker have shown the ability to develop large populations, which have previously been recorded at levels greater than 100,000 adults (Marsh *et al.* 2015). Abundance is typically measured as the number of adults per population present in the system. Additional indications of population resiliency are the documentation of varying life stages, including spawning and larval presence, presence of juveniles, the documentation of naturally recruited adults, and self-sustaining populations able to provide population stability.

3.7 Multiple, interconnected, naturally recruiting, and resilient populations (*Species need - Redundancy*)

Redundancy describes the ability of a species to withstand catastrophic events by spreading the risk among populations and is characterized by having multiple, resilient populations distributed across the range of the species (D. R. Smith *et al.* 2018). Redundant populations for razorback sucker exhibit use of multiple areas within a population range because all the populations defined in the SSA are geographically large (e.g. multiple bays in a reservoir, multiple rivers in a basin). Redundant populations in lotic systems occupy habitats across a geographic extent including the use of the mainstem and multiple tributaries. In lentic systems, few barriers exist across the reservoir other than the presence of nonnative fish, and razorback sucker are often present at multiple locations (e.g., tributary mouths) that could allow for recolonization in the event of catastrophe. Multiple, self-sustaining, proximal populations in different watersheds without major barriers between them (e.g., Green, Colorado rivers) is a favorable distribution arrangement for the species to allow transition of individuals among populations for genetic exchange and demographic rescue.

3.8 Genetic and ecological diversity (*Species need - Representation*)

Maintaining representation in the form of genetic and ecological diversity is important to maintain the capacity of the razorback sucker to adapt to future environmental changes. Genetic analysis of the species indicates that, although the different populations display slightly different genetic characteristics and levels of diversity, historical diversity (Dowling *et al.* 2012) appears to be well maintained. It is important to note that genetic data for this species is from the 1980's and 1990's, a period when populations of razorback sucker already were declining (Tom Dowling, Wayne State University, personal communication). The species demonstrates an ability to inhabit to lake and inflow environments and to persist where river habitats have been altered which points to important ecological diversity.

3.9 Summary of Species Needs

Overall, razorback sucker individuals need certain habitat characteristics including complex lotic or lentic habitat for spawning, juvenile rearing habitat, and adult habitat, suitable water temperature and quality, variable flow regimes (for lotic systems), and an adequate food supply. The habitat characteristics affect varying life stages of the species, which collectively define a population's resilience (Figure 6). The species needs multiple, resilient populations (*Redundancy*) and maintenance of genetic and ecological integrity (*Representation*).

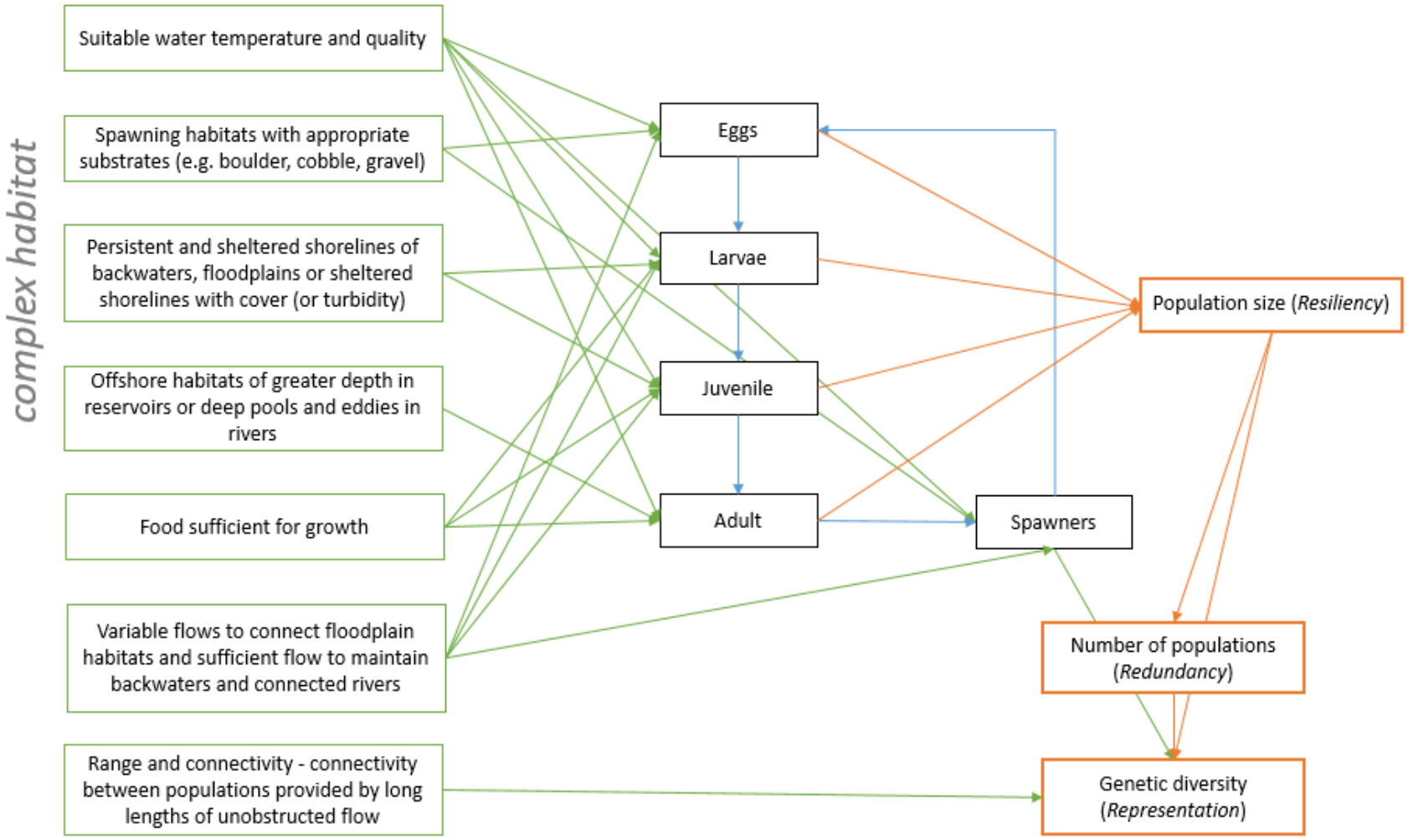


Figure 6. Flowchart of individual and population level needs (green) and the life stages they affect (black) in relation to species level needs of resiliency, redundancy, and representation (orange).

4 RISK AND CONSERVATION FACTORS

In this chapter, we evaluate the past, current, and future influences affecting razorback sucker current and future viability. Risks (or stressors) and conservation actions are explored to help explain both current and future condition of the razorback sucker across the eight populations in the upper and lower basins. The risks to razorback sucker include climate change, genetic factors (hybridization, inbreeding, reduced population size), habitat (flow regime/connectivity, land use, water management/habitat availability, and water temperature), nonnative and invasive species (competition, habitat effects, and predation), overutilization (use of species for various purposes), parasites and diseases, and pollutants (Figure 7). Conservation actions include augmentation, nonnative species management, program management and funding, research and monitoring, and water management / habitat availability (Figure 7). After risks and conservation actions were identified, an expert elicitation process (Delphi Process, Appendix A) was used to rank the factors most influential to razorback sucker over the next 30 years.

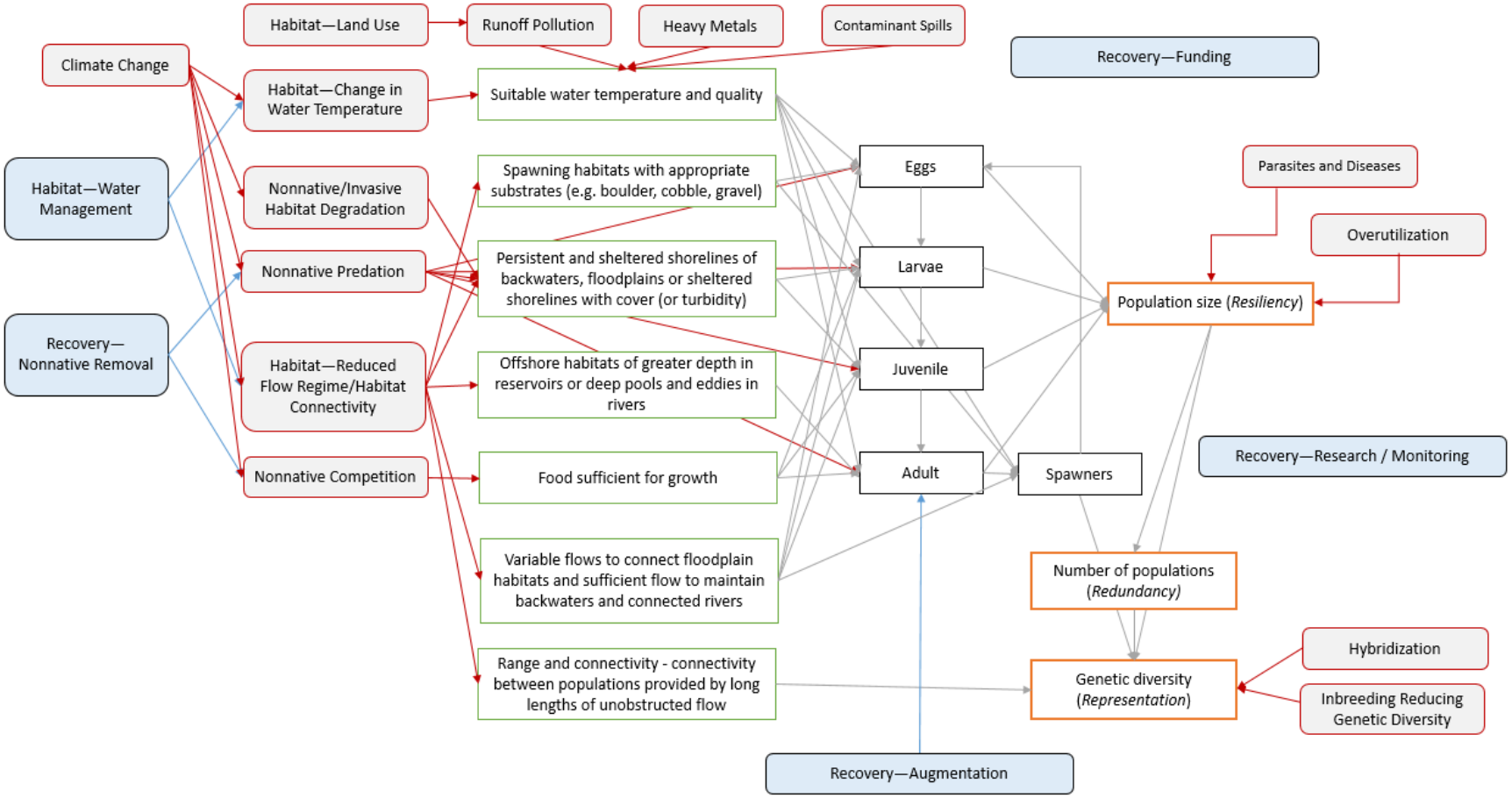


Figure 7. Flowchart of risks (gray with red outline) and management actions (blue rectangle) on razorback sucker individual and population needs (green outline) and their subsequent effects on the life stages (black outline) and 3Rs (orange outline). No lines are present connecting recovery program funding and research/monitoring to specific rectangles as they have overarching effects on the entire system.

4.1 Risks

4.1.1 Climate Change

Studies using predictive models indicate that changes in precipitation patterns, mean annual air temperature, and antecedent soil moisture will result in changes in flow patterns and magnitude in the Colorado River basin. Certain hydroclimate projections through 2099 (U.S. Bureau of Reclamation 2016b) indicate a slight increase in annual precipitation combined with an increase in mean annual temperature (Figure 8), while others project decreases in precipitation (nearly 6%) and associated snowpack (up to 76%) (Christensen *et al.* 2004), and resultant water supplies (Woodhouse et al. 2016). Even with a slight increase in annual precipitation, the risk of drought remains with continued temperature increases in the American Southwest (Christensen *et al.* 2004; Woodhouse *et al.* 2016; Ault *et al.* 2016). For example, an increase in mean annual air temperature of 2.4°C relative to historical climate in the Colorado River basin could decrease runoff by as much as 17% by 2098 (Nash and Gleick 1991; Christensen *et al.* 2004).(Nash and Gleick 1991; Christensen *et al.* 2004) Different combinations of changes in precipitation, temperature, and soil moisture can cause flow reductions of similar scales (Woodhouse et al. 2016); changes in climatic patterns can also result in earlier snowmelt and spring runoff, leaving summer base flows lower and warmer than they have been historically (Dennis 1991; Gleick and Chalecki 1999). The effects of a warming environment are already evident: between 2000 and 2014, Colorado River annual flows averaged 19.3% below the 1906-1999 period, one third of which was attributed to increased temperature alone (Udall and Overpeck 2017). Future conditions for razorback sucker could therefore include increased stream temperatures through reduced flows and increased air temperatures under drought conditions (Christensen *et al.* 2004; U.S. Bureau of Reclamation 2012; U.S. Bureau of Reclamation 2016b; U.S. Fish and Wildlife Service 2017).

The United States has experienced increased mean air temperatures of approximately 1.3 to 1.9°C since record keeping began in 1895, with most of the warming occurring since 1970 (U.S. Bureau of Reclamation 2016a). Continued warming throughout the 21st century is estimated to be 2.7 to 3.9°C (U.S. Bureau of Reclamation 2016a). As reported by the U. S. Fish and Wildlife Service (2017) and according to the Western Climate Mapping Initiative, during the 20th century mean air temperature increased approximately 1.2°C in the UCRB and approximately 1.7°C in LCRB. River water temperatures have also increased over the past decades. For example, from 1950 to 2015, mean annual water temperatures increased by about 13% in the Colorado River near Cisco, Utah and 11% in the Green River at Green River, Utah (U.S. Fish and Wildlife Service 2017). This was interpreted as decadal warming of about 1.5 °C in mean annual water temperatures in the Colorado River and 1.3 °C in the Green River (U.S. Fish and Wildlife Service 2017).

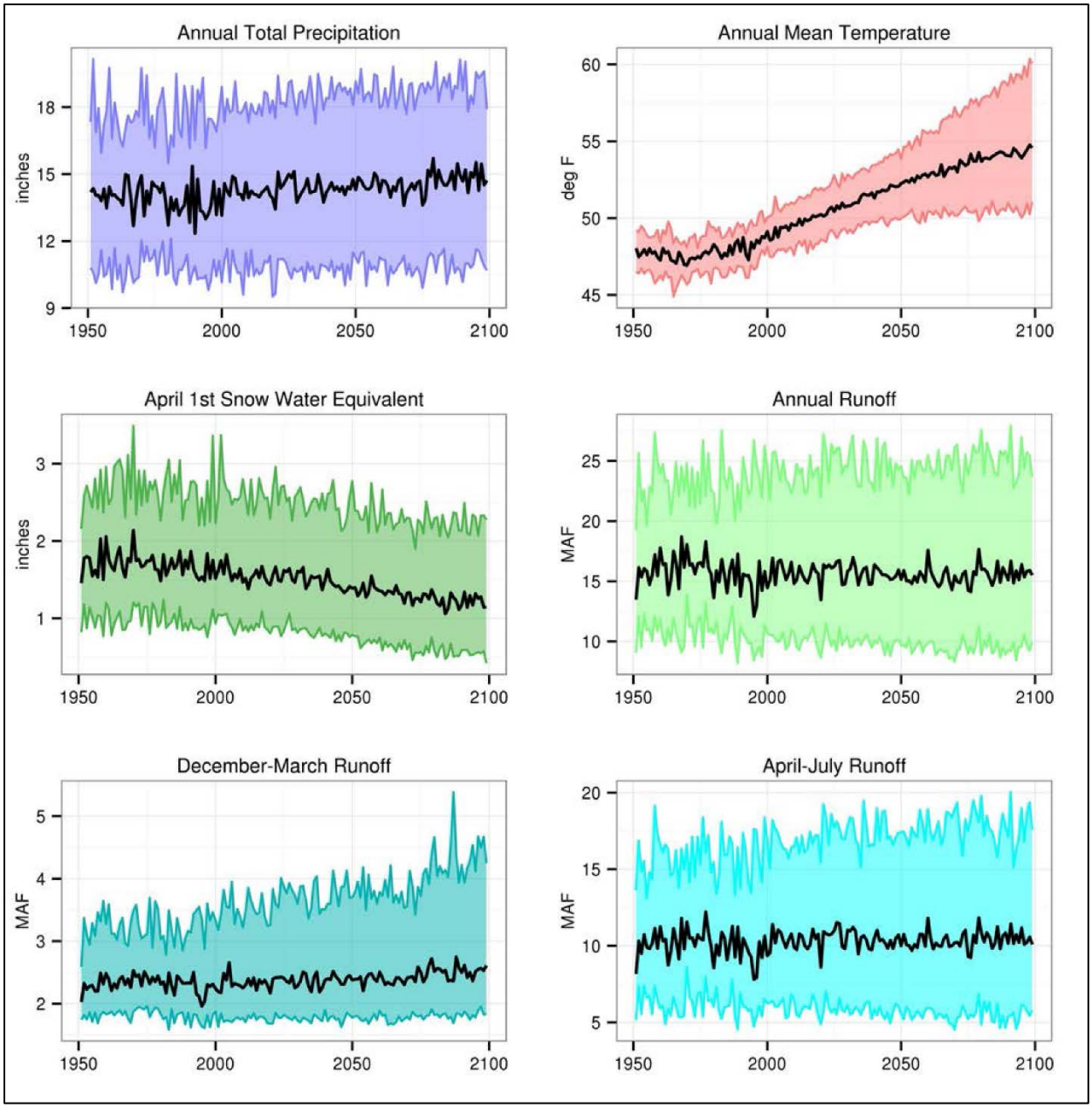


Figure 8. Time series plots for six projected hydroclimate indicators in the Colorado River basin from 1950-2099 (indicators title above each individual plot). The black line shows the annual time-series median value with the 10th and 90th percentiles shaded (Figure 1 from U.S. Bureau of Reclamation [Reclamation] 2016b).

In addition to altered stream temperatures, climate change could impact runoff conditions and annual hydrograph patterns, such as reduced April 1 snow water equivalent (Figure 8, middle left plot) and increased December to March runoff (Figure 8, bottom left plot). Altered hydrographs, especially decreased streamflow or earlier runoff would affect razorback sucker habitat, individuals, and populations. For example, decreased water quantity would decrease resource availability to individuals, increase competition with other fishes, and likely decrease water quality. In the upper basin, reduced runoff would reduce habitat-creating flows and earlier runoff could limit access to floodplain nursery habitats if peak flows occurred prior to larval razorback

sucker emergence (Bestgen *et al.* 2011; LaGory *et al.* 2012). Habitat changes could affect reproduction through decreased spawning habitat and reduction in survival and recruitment through increased predation and decreasing cover. In the lower basin, conditions in the Grand Canyon could become more suitable for razorback sucker as lower water levels in Lake Powell may increase temperatures and therefore increase habitat availability in the cool water stretches downstream of Glen Canyon Dam. However, increased introduction and expansion of warm-water nonnative fishes is also a risk under warming conditions in the Grand Canyon (Kegerries *et al.* 2015; U.S. Fish and Wildlife Service 2017).

Warming water temperatures, in conjunction with reduced stream flow, may also lead to increased growth rates and more rapid development of razorback sucker in some settings. However, warming water temperatures could also benefit survival, reproduction, and distribution of nonnative, warm-water species that are known to have negative impacts on razorback sucker survival and recruitment, such as smallmouth bass *Micropterus dolomieu* in the upper basin. Warm-water nonnative fish populations may further expand into areas currently occupied by razorback sucker. Although changes are expected to occur slowly over decades, the impact may be exacerbated if native fish temperature thresholds are exceeded while nonnative fishes are able to successfully reproduce and recruit in areas not currently occupied by nonnatives.

Razorback sucker's ability to spawn and recruit in both lentic and lotic habitats and reproduce at varying water temperatures suggests some tolerance and plasticity to climatic changes. For example, if stream conditions degrade, individuals may move to reservoir habitats, increasing the importance of reservoir inflow habitats to razorback sucker.

Overall, direct negative impacts from climate change primarily result from reduced runoff amounts or earlier peak flows, while indirect negative impacts are associated with increased production of nonnative fishes. Direct positive impacts from climate change includes warming of certain river reaches cooled by reservoir releases and potential increased growth rates.

4.1.2 Genetic Factors

4.1.2.1 Hybridization

Hybridization of species is relatively rare in nature, but may be more common in fishes than in other vertebrates (Helfman 2007). Hybridization disrupts the gene complexes, often producing individuals less adapted to local conditions, if offspring to survive and reproduce with the parental species, introgression can occur (Helfman 2007).

Native southwestern sucker species are known to hybridize with each other, which is not considered a significant threat to the species. Razorback sucker x flannelmouth sucker hybrids have long been recognized (Jordan 1891; Hubbs and Miller 1953; Vanicek *et al.* 1970; Holden 1973; Tyus 1990; G. R. Smith 1992) and are known to back-cross with other catostomid species (M. E. Douglas and Marsh 1998). Razorback x flannelmouth hybrids are caught near annually across the UCRB in small numbers (STReaMS 2016). Overlap in habitat use by razorback sucker, flannelmouth sucker, and bluehead sucker occurs in the lower Grand Canyon and Colorado River inflow area to Lake Mead and hybrid native suckers have also been documented (Albrecht *et al.* 2014; Kegerries *et al.* 2015). In the upper Colorado River, razorback sucker x bluehead sucker hybrids have been collected, but are rare (Travis Francis, U.S. Fish and Wildlife

Service, personal communication, May 2018). There is no evidence of bluehead and razorback sucker hybridization in the San Juan River, despite abundant populations of bluehead sucker (Turner *et al.* 2002; Schleicher 2016).

Populations of nonnative white sucker *Catostomus commersonii* are expanding in the upper Colorado River basin, which may lead to increased rates of hybridization with razorback sucker. White sucker readily hybridize with native flannelmouth sucker and bluehead sucker in the Yampa River and the Green River in Lodore Canyon (Bestgen *et al.* 2017). Researchers document downstream expansion of white sucker into reaches where razorback sucker are attempting to reproduce, such as the middle Green River (Staffeldt *et al.* 2017a) and portions of the upper Colorado and lower Gunnison rivers (Francis and Ryden 2017); this expansion may increase the hybridization threat to razorback sucker.

4.1.2.2 Inbreeding Reducing Diversity

Inbreeding is a well-known cause of extinction in small populations as inbreeding depression and loss of heterozygosity undermine components of the population (M. E. Gilpin and Soule 1986). Genetic integrity was measured in all populations (data from the 1990's) and was found to be higher in lower basin populations (Dowling *et al.* 2012). These data were used to create genetically diverse broodstock for the upper basin that were then used as the foundation of current stocking efforts. Because most populations rely on stocking as a conservation tool, management of broodstock is essential to maintain natural levels of diversity (Dowling *et al.* 1996). Hatcheries have procedures in place to ensure continuation of documented genetic levels, but periodic genetic assessments should be completed.

Lake Mohave's population is managed as a genetic refuge for the species as diversity levels within that population exceed all other populations. Genetic integrity is assessed to ensure that management actions retain or improve genetic diversity in Lake Mohave (Turner *et al.* 2007; Dowling *et al.* 2014; Carson *et al.* 2016). A number of metrics are commonly evaluated to assess the genetic integrity of populations including N_e (the genetic effective population size) and N_b (the annual effective number of breeders) (Dowling *et al.* 2014). If all adults in a population breed every year and contribute genes to the following generation, some minimum number of adults (N_b) would equal N_e. However, as with most populations, it is believed that not all razorback suckers spawn every year or contribute genes to the following generation, and hence, N_b is likely not equal to N_e. Estimates of N_b are available for some populations (Diver and Wilson 2018), but many remain unmeasured. Genetic viability is increased through maintaining natural connectedness and potential for gene flow among populations, regardless of size (Rieman and Dunham 2000).

Current threats to the genetic diversity of razorback sucker populations are thought to be minimal, as most populations are managed through propagation and stocking, assuming genetic management protocols as applied in hatcheries are adequate and routinely evaluated. Should natural recruitment begin to occur, other threats to genetic diversity may emerge. Given the estimated genetic effective population size, the only self-sustaining and recruiting population in Lake Mead is not of sufficient size to maintain genetic diversity long-term, however the genetics of this population are being monitored.

4.1.3 Alterations to Habitat

4.1.3.1 Altered Flow Regime

Numerous researchers identified that one of the major factors contributing to the decline of razorback sucker throughout their ranges has been the construction of mainstem dams and the resultant cool tailwaters, altered flow regimes, and reservoir habitats that replaced a once warm, dynamic, riverine environment (Holden and Stalnaker 1975; Joseph *et al.* 1977; Wick *et al.* 1982; W. L. Minckley *et al.* 1991). This change in the physical environment allowed for an increase in competition and predation from nonnative fishes, which are successfully established in the Colorado River and its reservoirs, and has contributed to native fish population declines (W. L. Minckley *et al.* 1991). Although reservoirs have supported the proliferation of nonnative species, the resultant lentic habitat may provide suitable habitat for razorback sucker, as evidenced by population documented during the filling of Lake Mohave and the continued presence of a recruiting population in Lake Mead.

Flow regimes in the Colorado River basin have been modified by dams and diversions that suppress spring runoff peaks and increase summer and winter base flows. Since roughly 1962, changes in spring peak runoff and base flows are as follows (U.S. Fish and Wildlife Service 2017):

- Upper Colorado River: spring peak decreased 33% and base flow increased 37%
- Green River: spring peak decreased 34% and base flow increased 76%
- Yampa River: spring peak decreased 4% and base flow increased 5%
- Lower Colorado River: spring peak decreased 70% and base flow increased 258%
- San Juan River: spring peak decreased 46% and base flow increased 168% (Holden 1999)

In the San Juan system, these flow changes have altered habitat through bank armoring and facilitating the establishment of nonnative vegetation. These changes have reduced habitat complexity that support razorback sucker life history (Bliesner and Lamarra 2007; Bliesner *et al.* 2008; V. A. Lamarra and Lamarra 2013). In the UCRB, spring peaks are reduced and earlier because of storage of spring runoff, while channelization and levee placement have further reduced frequency and duration of floodplain inundation. Floodplain habitats are important for young razorback sucker growth and survival. Thus, a main factor limiting razorback sucker recruitment and recovery is related to floodplain wetland habitat availability, which is controlled by spring flow levels.

The flow regimes in the Lower Colorado River are highly regulated by dams and the need for water delivery. It is estimated that changes to points of water diversion in the lower basin move 1.574 million acre-feet per year and results in 399 surface area acres of backwater being lost in areas once used by razorback sucker (U.S. Department of Interior 2005). The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) has conservation measures, which call for replacement, and management of these lost backwater habitats.

4.1.3.2 Land Use

Direct effects of land use are not a major risk to the condition of razorback sucker; that is, upland land use for agriculture, industrial, and municipal uses are not a primary risks to the species. The areas inhabited by razorback sucker are not densely populated by humans, and many stretches of river and reservoirs are protected by federal land ownership. Primary activities of upland land use are agricultural and energy development. These activities largely occur outside of river and reservoir habitats. Potential expansion of agriculture and further energy development in the basin could indirectly affect the species by increasing water use and decreasing flows available.

4.1.3.3 Reduced Water Temperature

The construction of mainstem dams created cool tailwaters unsuitable for egg and larval development. As noted above, rates of fish growth are dependent on the temperature at which they are reared (Bestgen 2008). Recruitment in cold, food-poor, high-velocity main channel habitat in spring is thought to be low in most years. However, recent collections of thousands of razorback sucker larvae in cold, Hoover Dam tailwaters near Willow Beach National Fish Hatchery are an apparent exception that should be noted (T. Delrose, LCR MSCP, email to LCRFish listserv, May 11, 2018).

Temperature recommendations and a temperature control device have been incorporated into the operation of Flaming Gorge Dam (Muth *et al.* 2000), but many mainstem systems remain impacted by cool tailwaters, including the Gunnison, San Juan and Colorado Rivers in the lower basin. Floodplain wetlands and backwaters are typically warmer than mainstem environments, underscoring their importance to early life stages of razorback sucker.

4.1.4 Nonnative Species

The introduction and proliferation of nonnative fishes create many direct and indirect impacts on native fishes of the southwestern United States, primarily from predation and competition but also through habitat alteration. Native fishes of the Colorado River basin appear to lack competitive and predator defense abilities compared to fishes that evolved in more species-rich regions (P. Martinez *et al.* 2014). The UCRB is currently occupied by approximately 50 nonnative fish species and the LCRB is occupied by approximately 20 nonnative species (Table 2) (Tyus *et al.* 1982; Lentsch *et al.* 1996; Valdez and Muth 2005). Several of these species present threats to razorback sucker at all life stages by preying on eggs, larvae, juveniles, and adults, competing for niche space, and altering the food web (Valdez and Muth 2005; Gozlan *et al.* 2010; P. Martinez *et al.* 2014).

4.1.4.1 Predation

Predation impacts most severely impact the larval to sub-adult life stages of razorback sucker. Outside of Lake Mead, and recent observations from the middle Green River in managed wetlands, there are few records of juvenile captures in the last 40 years. Because predation by nonnative fishes on young razorback sucker has been documented (Staffeldt *et al.* 2017a) and nonnative introduced predators are prevalent, predation at the larval and juvenile stages by nonnative piscivores is considered a major cause of low survival resulting in recruitment failure throughout the basin (Marsh *et al.* 2003; W. L. Minckley *et al.* 2003; Schooley, Karam *et al.* 2008; Ley *et al.* 2014; Ehlo *et al.* 2017). Expanding populations of smallmouth bass, flathead catfish, northern pike *Esox lucius,* striped bass *Morone saxatilis,* and channel catfish in reaches

where razorback sucker reproduce or are stocked may be a major obstacle to razorback sucker recruitment.

Contrastingly, depending on river reach and stocking history, annual adult survival has been estimated to be 70% or higher across the basin (Marsh *et al.* 2005; Zelasko *et al.* 2011; Zelasko *et al.* 2018). Evaluation of the upper basin stocking program from 2004 to 2007 demonstrated that size at stocking was positively correlated with survival (Zelasko et al. 2011), suggesting that predation risk is likely a large component of reduced survival of smaller individuals. Although predation by northern pike on larger stocked razorback sucker has been documented (pers. comm., K. Christopherson, Utah Division of Wildlife Resources), it does not seem to limit adult survival on a population scale. Additionally, abundant larvae have been produced annually in most reaches where adults occur; indicating that egg survival is not likely a limiting factor to razorback sucker.

Although predation pressure has likely limited razorback sucker recruitment for many decades, several examples suggest that recruitment of larvae to juvenile stages is possible under certain conditions, such as in managed pond and off-channel habitats free or relatively free of large bodied nonnative species. Locations with demonstrated survival of young life stages include Stewart Lake, (Green River subbasin in Utah), Imperial Ponds (lower Colorado River in Arizona), Cibola High Levee (lower Colorado River in Arizona) (W. L. Minckley *et al.* 2003; Schelly and Breen 2015; Schelly *et al.* 2016). Even in the absence of large-bodied nonnative predators, small-bodied nonnative fishes remain a concern. Predation on early life stages of catostomids in backwaters by green sunfish *Lepomis cyanellus* and red shiner *Cyprinella lutrensis* has been documented and doubtless also occurs in floodplain wetlands (Ruppert *et al.* 1993; Modde 1996; Christopherson *et al.* 2004; Modde and Haines 2005).

Although all nonnative fish species are problematic, research identified northern pike, smallmouth bass, and walleye *Sander vitreus* as the most problematic in the lotic portions of the Green and Colorado subbasins because of their high abundance, habitat use that overlaps with most native fishes, and ability to consume a wide variety of life stages of native fishes (Johnson *et al.* 2008; P. Martinez *et al.* 2014). Channel catfish *Ictalurus punctatus* are the most abundant lotic nonnative piscivorous fish in the San Juan basin, but recent studies have not documented population level effects on razorback sucker (Franssen *et al.* 2014).

Table 2. Nonnative fishes present in the upper and lower Colorado River basins and their relative abundance. (UCRB,data recreated from Valdez and Muth 2005).

Species	Scientific Name	UCRB	LCRB	Relative Abundance
Catostomidae (suckers)				
Utah sucker	*Catostomus ardens*	X		Common in some reservoirs; incidental-to-rare in some river reaches
longnose sucker	*C. catostomus*	X		Incidental-to-rare in some river reaches
white sucker	*C. commersonii*	X		Common in some reservoirs; locally common in some river reaches
Centrarchidae (sunfishes)				
green sunfish	*Lepomis cyanellus*	X	X	Locally common
bluegill	*L. macrochirus*	X	X	Common in some reservoirs; incidental-to-rare in some river reaches
redear sunfish	*L. microlophus*		X	Common in Lake Havasu
smallmouth bass	*Micropterus dolomieu*	X	X	Abundant in some reservoirs; common-to-abundant in some river reaches
largemouth bass	*M. salmoides*	X	X	Abundant in some reservoirs; incidental-to-rare in some river reaches
white crappie	*Pomoxis annularis*	X		Incidental
black crappie	*P. nigromaculatus*	X	X	Abundant in some reservoirs; incidental-to-rare in some river reaches
Cichlidae (cichlids)				
blue tilapia	*Oreochromis aureus*		X	Incidental-to-locally common
Clupeidae (herrings)				
gizzard shad	*Dorosoma cepedianum*	X	X	Abundant in reservoirs, becoming more common in riverine reaches
threadfin shad	*D. petenense*	X	X	Common in reservoirs and tributary inflows
Cyprinidae (minnows)				
goldfish	*Carassius auratus*	X		Incidental
grass carp	*Ctenopharyngodon idella*	X		Incidental
red shiner	*Cyprinella lutrensis*	X	X	Widespread, common-to-abundant
common carp	*Cyprinus carpio*	X	X	Widespread, common-to-abundant; uncommon in San Juan River
Utah chub	*Gila atraria*	X		Abundant in Flaming Gorge Reservoir; incidental-to-rare in some river reaches
brassy minnow	*Hybognathus hankinsoni*	X		Incidental
plains minnow	*H. placitus*	X		Incidental
Southern leatherside chub	*Lepidomeda aliciae*	X		Incidental

Species	Scientific Name	UCRB	LCRB	Relative Abundance
golden shiner	*Notemigonus crysoleucas*	X		Incidental
sand shiner	*Notropis stramineus*	X		Common-to-abundant
fathead minnow	*Pimephales promelas*	X	X	Widespread, common-to-abundant
bullhead minnow	*P. vigilax*	X		Incidental
longnose dace	*Rhinichthys cataractae*	X		Incidental
redside shiner	*Richardsonius balteatus*	X		Rare-to-common in upper reaches of some rivers
creek chub	*Semotilus atromaculatus*	X		Incidental-to-rare
Cyprinodontidae (killifishes and pupfishes)				
plains topminnow	*Fundulus sciadicus*	X		Incidental
plains killifish	*F. zebrinus*	X		Incidental
rainwater killifish	*Lucania parva*	X		Incidental
Esocidae (pikes)				
northern pike	*Esox lucius*	X		Abundant in Yampa River, common in Upper Green, rare elsewhere in UCRB
Gadidae (cods)				
burbot	*Lota lota*	X		Incidental in Flaming Gorge Reservoir and river upstream
Gasterosteidae (sticklebacks)				
brook stickleback	*Culaea inconstans*	X		Locally incidental
Ictaluridae (catfishes)				
black bullhead	*Ameiurus melas*	X	X	Incidental-to-locally common
yellow bullhead	*A. natalis*	X	X	Common in reservoirs
brown bullhead	*A. nebulosus*	X		Incidental
flathead catfish	*Pylogictis olivaris*		X	Common in Lake Havasu, and below Parker Dam
channel catfish	*Ictalurus punctatus*	X	X	Widespread, common-to-abundant
vermiculated sailfin catfish	*Pterygoplichthys disjunctivus*		X	Localized and incidental
Moronidae (temperate basses)				
white bass	*Morone chrysops*	X		Incidental-to-rare
striped bass	*M. saxatilis*		X	Abundant in reservoirs/tributary inflows
Percidae (perches)				
Iowa darter	*Etheostoma exile*	X		Incidental
Johnny darter	*E. nigrum*	X		Incidental

Species	Scientific Name	UCRB	LCRB	Relative Abundance
yellow perch	*Perca flavescens*	X		Common in some reservoirs; incidental-to-rare in some river reaches
walleye	*Sander vitreus*	X		Common in some reservoirs; common in some river reaches
Poeciliidae (livebearers)				
western mosquitofish	*Gambusia affinis*	X	X	Incidental to locally common
Salmonidae (trout and salmon)				
Yellowstone cutthroat trout	*Oncorhynchus clarkii bouvieri*	X		Incidental-to-rare in cool streams
greenback cutthroat trout	*O. c. stomias*	X		Incidental-to-rare in cool streams
coho salmon	*O. kisutch*	X		Common in some cold reservoirs
rainbow trout	*O. mykiss*	X	X	Rare-to-common in cool river reaches; actively stocked
Kokanee	*O. nerka*	X		Common in cold reservoirs
brown trout	*Salmo trutta*	X	X	Rare-to-common in cool river reaches
brook trout	*Salvelinus fontinalis*	X		Rare-to-common in cool streams
lake trout	*S. namaycush*	X		Abundant in some cold reservoirs

Large-bodied predators emerged in the UCRB as threat approximately 25 years ago, as species introduced for sportfishing opportunities began to colonize river habitats, primarily by escaping from reservoirs in which they were stocked. Populations of northern pike expanded in the Yampa River in the 1990s; smallmouth bass increased in abundance in the Yampa River after persistent drought in the early 2000s with subsequent colonization of other habitats in the Green, Duchesne, White, and Colorado rivers during drought conditions in the early 2000s (Hawkins *et al.* 2005; Breton *et al.* 2013). Since approximately 2008, walleye have established relatively high densities in razorback sucker nursery habitats of the lower and middle Green River and the lower portions of the upper Colorado River (Francis and Ryden 2014; Francis and Ryden 2015; Jones, Haines et al. 2015; Schelly and Breen 2015a). Drought conditions in the early 2000s caused Lake Powell to recede and a waterfall to form, blocking access of all fishes to the San Juan River. Nonnative removal in the San Juan River has primarily focused on reducing populations of common carp *Cyprinus carpio* and channel catfish; carp have dramatically declined in response, but a large, resident channel catfish population persists (Hines 2015; Pennock *et al.* 2018).

Reservoir habitats are dominated by nonnative fishes, primarily managed as sportfishing opportunities. For example, Lake Powell is inhabited primarily by nonnative predatory sport fish, such as walleye and striped bass, which may pose considerable limitations to in-lake razorback sucker recruitment (Albrecht *et al.* 2017) . However, recruitment within Lake Mead suggest that recruitment is possible, even in the presence of nonnative fishes (Albrecht *et al.* 2010; Mohn *et al.* 2015).

As in the UCRB, predation by and competition with nonnative fish species are major threats to razorback sucker recruitment in the LCRB. Approximately 20 nonnative fish species (Table 2) species occupy razorback sucker habitats, both in riverine and reservoir environments, with varying impacts to razorback sucker individuals. While larval and juvenile razorbacks are vulnerable to predation by nearly all introduced fishes, certain species impact larger life stages. For example, flathead catfish prey on razorback suckers of all sizes, and likely preclude the establishment of razorback sucker populations in areas where they are widespread and abundant (such as the Verde River and Colorado River downstream from Lake Havasu).

Predation of native fish by catfish, trout, and striped bass has been documented in the Grand Canyon (Kaeding and Zimmerman 1983; Valdez and Ryel 1995; M. E. Douglas and Marsh 1996; C. O. Minckley 1996; Valdez and Carothers 1998), but is thought to be a low risk to razorback sucker that inhabit areas dominated by native fishes. However, over the past 5 years, native fish have been dominant in the Grand Canyon below the Little Colorado River inflow. Furthermore, recent sampling below Lava Falls reports small-bodied nonnative abundance in nearshore habitats to be less than 12% of the total (Albrecht *et al.* 2014b; Kegerries *et al.* 2015a). Because of an apparent lack of diverse food items and a longitudinal pattern in food-web dynamics (Cross *et al.* 2013), it is likely that competition among all fish species is occurring, demonstrating that competition with other native fishes can be a consideration as well. The threat of nonnative fishes in the Grand Canyon is not certain to remain low. In fact, escapement of nonnative fishes from Lake Powell through the dam penstocks and generators of Glen Canyon Dam has been projected to possibly increase as reservoir elevation becomes lower and warm epilimnetic water is entrained (U.S. Department of the Interior 2010).

The fish communities in the river arms of Lakes Powell and Mead, where populations of razorback sucker are concentrated, consist of over 20 fish species as assessed through trammel netting efforts (data from Albrecht *et al.* 2017) (Figure 6). All but four of those species (razorback sucker, flannelmouth sucker, bluehead sucker, and Colorado pikeminnow) are nonnative fish. At each location, razorback sucker made up a small percentage of the total catch, but were as abundant as other native suckers. Gizzard shad *Dorosoma cepedianum*, common carp, bluegill *Lepomis macrochirus*, channel catfish, striped bass, smallmouth bass, and largemouth bass *Micropterus salmoides* were the most abundant species, demonstrating the dominance of nonnative species in these habitats (data from Albrecht *et al.* 2017).

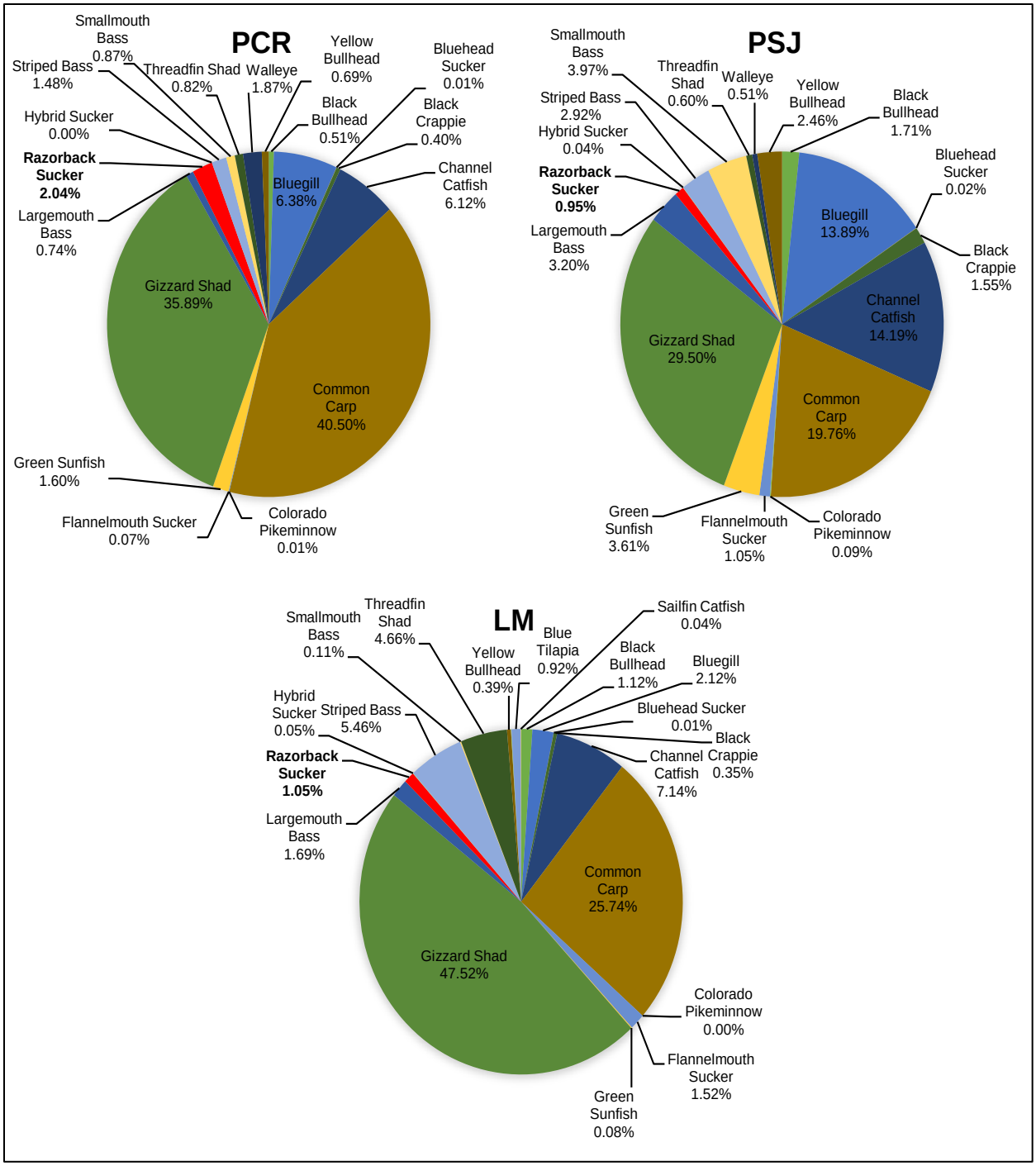


Figure 9. Fish community composition from trammel net captures at the Colorado River arm of Lake Powell (PCR) in 2014 and 2015, the San Juan River arm of Lake Powell (PSJ) in 2011 and 2012, and Lake Mead (LM) from 2005 to 2016.

Lake Mohave is managed as a sport fishery by the states of Arizona and Nevada for largemouth bass, smallmouth bass, striped bass, rainbow trout *Oncorhynchus mykiss*, bluegill, green sunfish, and channel catfish. The Lake Mohave population of razorback sucker spawns annually but recruitment has not been documented since the 1950s (Marsh and Langhorst 1988; Mueller

2006; Karam and Marsh 2010). Striped bass, as well as sunfish, may play a role in population declines throughout Lake Mohave (Karam and Marsh 2010; Kesner *et al.* 2012); predation of a 500 mm razorback sucker by striped bass was documented when an angler found an acoustic transmitter in a striped bass stomach. Sunfish have been implicated in lack of survival of young razorback sucker.

Lake Havasu is managed as a sport fishery by the state of Arizona, which supports populations of largemouth bass, smallmouth bass, striped bass, bluegill, and redear sunfish. Other nonnatives present in Lake Havasu, but which are not actively managed, include green sunfish, yellow bullhead *Ameiurus melas*, flathead catfish, and channel catfish.

Predation by nonnative catfish was studied in the Gila River, documenting predation of multiple razorback sucker by 55% of channel catfish and 90% of flathead catfish studied (Marsh and Brooks 1989). Thus, in the Gila River, predation likely accounts for the poor success of razorback sucker repatriation (Marsh and Brooks 1989). Additionally, short-term mortality and the lack of long-term survival in the Colorado River below Parker Dam due to predation by fish (including flathead catfish) and birds led to a recommendation to limit stocking to only predator-free habitats (Schooley, Kesner *et al.* 2008). Stocking efforts were eventually abandoned in the basin as no evidence of long-term survival was found.

4.1.4.2 Competition

Nonnative species have a variety of traits that allow them to effectively compete for niche space, including a lack of dependence on fluvial conditions to complete the life cycle, preference for slow currents and warm water, omnivorous behavior, variable spawning substrate requirements, maturation at an early age and smaller size, production of smaller effs that hatch quickly, and larger swim factors (Olden *et al.* 2006). Razorback sucker have similar characteristics in a preference for slow and warm currents and a wide diet breadth, opening them to competition from a variety of species including common carp and channel catfish (Olden *et al.* 2006). Competition between native and nonnative species is known to occur occurs in the Colorado River basin (Tyus and Saunders 2000; Carpenter 2005), but there is little information documenting the effect of competition isolated from predation. For example, red shiner and fathead minnow *Pimephales promelas* are common in backwaters and floodplains and are thought to be of concern because of their aggressive nature (Karp and Tyus 1990; Tyus and Saunders 2000), but are also known to prey on larval razorback sucker.

4.1.4.3 Habitat effects

Habitat is affected by invasions of both plant and animal species, with varying effects depending on the invasive species. Riparian habitats are considered especially prone to invasion by plant species, which can alter both the hydrology and fluvial geomorphology of a riverine system (Tickner *et al.* 2001). After dam construction and the elimination of large flood events, Tamarix species expanded across the western U.S. corresponding with substantial decreases in visible sandbars and gravel in stream channels (Brock 1994). Invasive aquatic species such as common carp or dreissenid mussels can also affect habitat by modifying water quality and trophic structures (Higgins and Zanden 2010; Kloskowski 2011). Although invasive species have altered habitat throughout the Colorado basin, the effects on razorback sucker are thought to be limited in comparison to predation.

4.1.5 Overutilization

Although early historical reports razorback sucker as being harvested in great quantities by fishing (W. L. Minckley 1973), razorback sucker are not currently used for commercial, recreational, or educational purposes. Razorback sucker are protected by state fishing regulations, requiring anglers to return individuals to the water upon catch (New Mexico Department of Game and Fish 2016; Colorado Parks and Wildlife 2018; Utah Division of Wildlife Resources 2018; Nevada Department of Wildlife 2018; Arizona Game and Fish Department 2018). The impacts of electrofishing and associated handling occurring throughout the basin (for both research/monitoring and nonnative fish removal) could be affecting the razorback sucker, especially during spawning. Protocols for sampling in the UCRB have been refined to limit fish stress, and electrofishing is prohibited on active spawning locations.

4.1.6 Parasites and Diseases

Common ailments among razorback sucker populations include a host of parasites (protozoans, parasitic worms, and copepods) and blindness (W. L. Minckley *et al.* 1991). Asian tapeworm *Bothriocephalus acheilognathi* has been detected in nonnative species in the Little Colorado River basin, which joins with the Colorado River in the Grand Canyon (Stone *et al.* 2007). Further studies indicate it may be present in the upper Colorado River basin as well (Choudhury *et al.* 2006). Parasites and disease are thought to be of limited concern for razorback sucker recovery (W. L. Minckley *et al.* 1991).

4.1.7 Pollutants

Natural and human factors such as climate, geology, soils, water management, and land use affect water quality. In general, water temperature, sediment, salinity, nitrogen, and phosphorus concentrations increase from upstream to downstream within the basin. A number of contaminants enter the Colorado River on a regular basis from municipal, industrial, historical mining and agricultural sources. Discharges from municipal and industrial sources are regulated by permit and must meet state and federal instream water quality standards, including standards protecting the most sensitive aquatic species. Water quality standards for permitted municipal and industrial discharges into habitat of endangered species are subject to consultation under the ESA to ensure protection of endangered species. Unregulated discharges, such as historical mining sites are present throughout the basin and have been mapped and quantified for some subbasins (Church 2007).

4.1.7.1 Metal Toxicity

Selenium naturally occurs in the environment and is required for normal growth and development; however, elevated levels can have detrimental effects. If selenium bioaccumulates, toxic levels can cause deformities and decreased reproductive success in fish (Hamilton 2004). Selenium has been documented in high concentrations in mainstem and wetland habitats of the UCRB since the 1930s, and its adverse biological effects on both larvae and adult razorback sucker have been documented (Hamilton 1998; B. C. Osmundson *et al.* 2000).

Considerably more selenium is found in the Colorado River above the Green River confluence than in the Green and San Juan river basins of the UCRB. Selenium remediation has been implemented in the Gunnison River, and sources of selenium have been identified within the Green River (e.g., Stewart Lake; (U.S. Fish and Wildlife Service 2017)).

The LCRB contains some of the highest selenium concentrations in the nation (Radtke *et al.* 1988; Hamilton 1998). Fish tissue samples from Lake Mead, Lake Havasu, Imperial Reservoir, and the Colorado River near Yuma exceeded water quality standards for selenium concentration. Samples from the Gila River (San Carlos Reservoir) did not, assessed at the 85th percentile of concentrations measured. Elevated concentrations of selenium are found near Imperial Dam (Engberg 1999). In the LCRB, reservoir and backwater habitats have been and continue to be monitored for water quality purposes.

4.1.7.2 Runoff Pollution

Runoff pollution is caused when rainfall or snowmelt, moving over the ground, picks up natural or man-made pollutants, depositing them into nearby waterbodies. Runoff from agricultural and undeveloped areas are not managed through the discharge permitting process and are therefore unregulated. Little is known about the full suite of compounds and chemicals present in runoff throughout the basin, but a few studies have been conducted to examine the impacts of certain activities on certain in-stream loads. Oil and gas development in the basin are expected to have little effect on dissolved-solid loads in comparison to undisturbed land (Buto *et al.* 2010). Irrigation and its associated runoff are thought to be responsible for 71% of the selenium reaching Lake Powell (Engberg 1999). Although mostly meeting state and federal water-quality guidelines, exceedances of trace elements (cadmium, zinc, copper, lead and selenium) do occur across the basin (Spahr 2000). Elevated levels of selenium, mercury, and pesticides have been found in nonnative fish samples from across the Colorado River basin (Hinck *et al.* 2007). The study also documented the presence of intersex fish, which may indicate presence of endocrine disrupting compounds (Hinck *et al.* 2007). The effects of current or emerging contaminants on reproductive success or health of razorback sucker is unknown.

4.1.7.3 Contaminant Spills

Catastrophic spills of hazardous materials, such as petroleum products or other chemicals are a potential threat to water quality throughout the Colorado River basin. The Denver and Rio Grande Western railroad tracks have paralleled the Colorado River at Black Rocks and upper Westwater Canyon since ~1883 (Bradley 1996); these pose a risk of derailment and spills of materials into the river, although no known derailment has occurred in these areas. Numerous petroleum-product pipelines cross or parallel rivers in the upper basin. Existing and future oil and gas wells located near floodplains, arroyos, or washes are another potential spill source. The susceptibility of habitats to these spills is demonstrated by the 2014 well rupture near Green River, UT that spilled petroleum compounds into the Green River where razorback sucker are common[2]. HAZMAT plans exist for states of the Colorado River basin, but have not been reviewed or evaluated to determine how they would be implemented to mitigate contaminant spills.

[2] http://www.moabsunnews.com/news/article ce055ca4-e673-11e3-be35-001a4bcf6878.html

Ash or debris flows from large rainstorms following rangeland fires are a more natural catastrophic threat to razorback sucker in the basin. These flows can deliver large amounts of mud, ash, and debris that can suffocate fish and macroinvertebrates; these debris flows often occur after fires have denuded the landscape of vegetation and may contain fire retardant chemicals that could cause toxic fish effects. Wildfires have been shown to liberate accumulated heavy metals and increase nutrient loading into streams (Bladon *et al.* 2014).

4.2 Ongoing and Future Conservation Actions

The following four programs in the Colorado River basin are designed to balance demands for water and power while protecting natural resources and conserving and/or recovering endangered fish, including razorback sucker.

- The Upper Colorado River Endangered Fish Recovery Program (UCREFRP) is recovering the humpback chub, Colorado pikeminnow, razorback sucker, and bonytail upstream of Lake Powell. The program was established in January 1988. The UCREFRP is a unique partnership of local, state and federal agencies, water and power interests and environmental groups. The program is authorized through 2023. Recovery efforts for razorback sucker are implemented each year through the Program's annual budgeting and work plan process. Specific activities are defined in the Recovery Implementation Program/Recovery Action Plan (RIP/RAP), including augmentation, flow and habitat management, nonnative fish control and monitoring consistent with the razorback sucker Recovery Plan (U.S. Fish and Wildlife Service 2002).

- The San Juan River Basin Recovery Implementation Program (SJRIP) is recovering the Colorado pikeminnow and razorback sucker and is specific to the San Juan River, including the San Juan River arm of Lake Powell. The program was established in 1992 and is funded through 2023. All recovery efforts for razorback sucker are outlined each year through this program's Long-Range Plan (San Juan River Basin Recovery Implementation Program 2016).

- The Glen Canyon Dam Adaptive Management Program (GCDAMP) was established in 1997 and coordinates research and monitoring activities aimed at protection of natural resources of the Colorado River through the Grand Canyon, including activities to benefit the humpback chub and razorback sucker from Glen Canyon Dam to the Lake Mead inflow. The GCDAMP is not a recovery program but instead makes recommendations to the Secretary of the Interior in compliance with the Grand Canyon Protection Act and environmental commitments for operation of Glen Canyon Dam. The funding is currently legislated without sunset (U.S. Department of the Interior 2016).

- The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is a partnership of federal and non-federal stakeholders created in 2005 to respond to the need to balance the use of lower Colorado River (LCR) water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act (ESA). The program coordinates conservation of multiple species, including the

humpback chub, razorback sucker, and bonytail, from the Lake Mead inflow to the border with Mexico. The program provides ESA compliance through a Habitat Conservation Plan, where actions provided by the program address adverse effects on covered species that may result from all federal and non-federal actions that occur in the geographic area of the program (U.S. Department of Interior 2005). This program is currently set to expire in 2055 and annual work plans, budgets, and progress reports document efforts directed towards conservation of razorback sucker and other species.

Other smaller programs, funding sources, or conservation entities include the Gila River Basin Conservation Program, the Salt River Project's Horseshoe-Bartlett Habitat Conservation Plan (helps to support conservation in the Verde River), the Lake Mohave Native Fish Workgroup, the Lake Mead Razorback Sucker Workgroup, and other similar working groups.

The 2002 recovery goals for razorback sucker (U.S. Fish and Wildlife Service 2002) outline the need for conservation agreements to be in place as delisting occurs, emphasizing the importance of management to this and other species.

> *Conservation plans will go into effect at delisting to provide for long-term management and protection of the species, and to provide reasonable assurances that recovered razorback sucker populations will be maintained without the need for relisting. Elements of those plans could include (but are not limited to) provision of flows for maintenance of habitat conditions required for all life stages, regulation and/or control of nonnative fishes, minimization of the risk of hazardous-materials spills, and monitoring of populations and habitats. Signed agreements among State agencies, Federal agencies, American Indian tribes, and other interested parties must be in place to implement the conservation plans before delisting can occur.*

The UCREFRP, SJRIP, GCDAMP, and LCR MSCP have implemented a suite of actions that benefit a variety of species. Many actions specific to razorback sucker match fourteen actions deemed necessary in the 2002 recovery goals:

1. Reestablish populations with hatchery-produced fish.
2. Identify and maintain genetic variability of razorback sucker in Lake Mohave.
3. Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations.
4. Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion.
5. Investigate options for providing appropriate water temperatures in the Gunnison River.
6. Minimize entrainment of subadults and adults at diversion/out-take structures.
7. Ensure adequate protection from overutilization.
8. Ensure adequate protection from diseases and parasites.
9. Regulate nonnative fish releases and escapement into the main river, floodplain, and tributaries.
10. Control problematic nonnative fishes as needed.
11. Minimize the risk of hazardous-materials spills in critical habitat.

12. Remediate water-quality problems.
13. Minimize the threat of hybridization with white sucker.
14. Provide for the long-term management and protection of populations and their habitats beyond delisting (i.e., conservation plans).

Below is a general summary of conservation actions implemented by these programs, ranked as most impactful to razorback sucker (Delphi process, Appendix A). Actions that were not called out in the Delphi process are noted under Program Management and Funding (Section 4.2.2)

4.2.1 Water Management

The UCREFRP and the SJRIP continue to work with partners to adaptively manage flows to benefit razorback sucker and other native fishes. Flow recommendations have been developed for most major rivers of the UCRB (Holden 1999; Muth *et al.* 2000; McAda 2003), coupled with temperature recommendations in the Green River. These recommendations are evaluated through a series of UCREFRP and SJRIP studies that are coordinated through study plans (ad hoc Committee 2007; ad hoc Committee 2011). Technical committees evaluate each study and recommend further actions through the programs' annual planning documents.

Flow recommendations for Flaming Gorge are specified by reach, by condition and by hydrologic condition (Muth et al. 2000). Temperature recommendations are in place in Reach 1 (above the confluence with the Yampa River) and recommend less than 5 C difference between the Green River and the Yampa River to prevent thermal shock (Muth et al. 2000). In addition, spring flow management (larval trigger study plan [LTSP]) in the middle Green River has been refined in recent years by timing spring peak releases to better coincide with real-time emergence of larval razorback sucker, which helps entrain them into flooded wetland habitats (Bestgen *et al.* 2011; LaGory *et al.* 2012). Floodplain wetlands are warm, food-rich floodplain areas, which are likely important rearing and resting habitat for early and adult life stages of spring-spawning razorback sucker, and may enhance recruitment (Modde *et al.* 1996; Muth *et al.* 1998; Bestgen *et al.* 2002; Bestgen *et al.* 2011). Since implementation in 2012, results of LTSP have been largely positive and the survival of age-0 razorback sucker into the winter is now frequently documented at Stewart Lake (Schelly *et al.* 2014; Schelly and Breen 2015; Schelly *et al.* 2016; Staffeldt *et al.* 2017b). Efforts to improve the function of other UCRB wetlands are ongoing.

Various water agreements and coordinated water management activities have been implemented in the upper Colorado River basin to augment flows along key river reaches for the benefit of endangered fish, including razorback sucker. These include measures to augment annual spring high flows in the Green, Gunnison, and mainstem Colorado Rivers (see Section 5.1.2), and to augment late-summer base flows in these rivers, as well as the Yampa and Duchesne rivers. Since 1998, more than 1.5 million acre-feet of water has been delivered to the 15-Mile Reach of the mainstem Colorado River pursuant to various agreements and commitments for base flow augmentation during the July-through-October low-flow season. Similarly, the U.S Bureau of Reclamation's (Reclamation) modified reservoir operations for their Aspinall Unit dams (U.S. Fish and Wildlife Service 2009a) and Flaming Gorge Dam (U.S. Department of Interior 2006) have collectively resulted in the augmentation and/or re-timing of millions of acre-feet of

instream flow to benefit the endangered fish and their habitats. All flow enhancements are voluntary.

Along with these flow augmentation and flow re-timing actions, the UCREFRP has also helped fund and facilitate projects in the Upper Basin, which improved water management and allowed for more precise control over water diverted into irrigation systems. For example, extensive improvements in irrigation efficiencies have been realized since the late 1990's by two large irrigation districts in the Grand Valley of Colorado: the Grand Valley Water Users Association and the Orchard Mesa Irrigation District, in part through UCREFRP funding. These improvements include miles of lined canals, multiple check dams, reregulating reservoirs, and computer-based ("SCADA") systems for better real-time monitoring and control of irrigation diversions and deliveries. Collectively, these improvements leave water undiverted or returned to the mainstem of the Colorado River and its upstream reservoirs, often amounting to tens of thousands of acre-feet annually, allowing this water to be bypassed or delivered at times and places that better satisfy the flow targets for the endangered fish. Similarly, improvements made in 2017 to the headgate and delivery canals associated with the Maybell Irrigation District's irrigation system along the Yampa River should substantially reduce occurrences of over-diversion from that river, leaving more instream flow to benefit fish.

In the Grand Canyon, Glen Canyon Dam, releases are coordinated through operating criteria outlined in the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations of Lake Powell and Lake Mead Environmental Impact Statement (EIS) (U.S. Department of the Interior 2007), with additional guidance for resource protection by the Long-Term Experimental and Management Plan EIS (U.S. Department of the Interior 2016). All other dams in the lower basin are managed for hydropower.

4.2.2 Program Management and Funding

Authorizing legislation for all four programs and financial commitments from their partnering entities currently provide funding for the three components identified above and below (i.e. 4.2.1, 4.2.3 – 4.2.5) as well as additional actions deemed important by the programs.

The UCREFRP and SJRIP are staffed by U.S. Fish and Wildlife Service employees, but work is prioritized using committee structures comprised of representatives from other federal agencies, states, water users, and environmental groups (and Tribal representatives in the SJRIP). Between 1989 and 2018, the UCREFRP spent over $394 million dollars on recovery actions including habitat restoration, nonnative fish management, research and monitoring, propagation and genetics management, instream flow protection and education and outreach. Between 1992 and 2018, the SJRIP spent over $78 million dollars on similar projects. Both programs are funded by power revenues from Western Area Power Administration, Reclamation, the U.S. Fish and Wildlife Service, participating states, and other partners specific to each program. The funds are spent on capital projects like fish screens, passage devices or habitat modifications as well as annually funding perpetual activities such as monitoring or nonnative fish removal (Fischer 2018).

All four programs provide some measure of protection or improvement of habitats occupied by razorback sucker. Habitats occupied by razorback sucker fall under the management of all federal land management agencies and various Native American Tribes. Critical habitat has been designated for the species in the UCRB and LCRB (including reaches in the Gila basin), requiring federal agencies to consult with USFWS before modifications can be made. Several floodplain habitats have been developed in the Green River subbasin including Stewart Lake, Johnson Bottom, and Sheppard Bottom and are managed to entrain larval razorback sucker in conjunction with LTSP, all of which are located close to Vernal, Utah. Additional habitats are being explored for development in the basin (Speas *et al.* 2017). Habitat restoration activities involving modification of floodplain wetlands for razorback sucker use are currently being considered in the Colorado River near Moab, UT and in the San Juan River.

Fish-passage structures have been installed on the Gunnison, upper Colorado, Green, and San Juan rivers. These structures allow native fish to access the upstream reaches of their historical ranges and could allow for population increases and expansions, providing water temperatures are adequate. Fish screens or weir walls have been installed in canals in the upper basin to reduce entrainment of fish in the Gunnison, upper Colorado, Green, and San Juan rivers. These structures reduce the loss of native fishes when water is released onto fields for irrigation and the fish otherwise become stranded in seasonally dried canals. The remaining open canal on the Green River is scheduled to be screened in 2019.

LCR MSCP management is housed in Reclamation in Boulder City, Nevada. The program's estimated cost is $626 million (in 2003 dollars), which is paid for by the Federal Government and the states of Arizona, California and Nevada (Lower Colorado River Multi-species Conservation Program 2018). The program is focused on creating at least 8,132 acres of new habitat (5,940 acres of cottonwood-willow, 1,320 acres of honey mesquite, 512 acres of marsh, and 360 acres of backwater) and producing 660,000 subadult razorback suckers and 620,000 bonytail to augment the existing populations of these fishes in the LCR. Under the LCR MSCP, participation in the recovery programs for these fishes may also include funding other appropriate activities in lieu of stocking. In addition, there is a substantial research and monitoring component to this program; a $25 million fund was established to support projects implemented by land use managers to protect and maintain existing habitat for covered species (Lower Colorado River Multi-species Conservation Program 2018).

Conservation areas that are being developed by LCR MSCP primarily as disconnected backwaters for native fishes, prioritize (1) delivery of non-native fish-free replacement water and (2) the ability to completely drain and renovate ponds without the use of piscicides (Lower Colorado River Multi-species Conservation Program 2018). There is also value in connected backwaters, and the creation of connected backwaters is an option in Reaches 3–5. Restoration research priorities for backwater development are expected to include researching water screening to exclude non-native fishes, maintaining water quality in isolated backwaters, and controlling non-native fish species (Lower Colorado River Multi-species Conservation Program 2018).

4.2.3 Nonnative Removal and Control

The UCREFRP and the SJRIP are working to reduce the numbers of nonnative fishes, focusing primarily on smallmouth bass, northern pike and walleye in the Green and upper Colorado subbasins and channel catfish in the San Juan. A comprehensive nonnative fish control strategy was developed by the UCREFRP encompassing active removal from riverine habitats, escapement prevention from upstream reservoirs, revised stocking guidelines, harvest regulation changes, and outreach messaging (P. Martinez *et al.* 2014). In 2018, nonnative fish removal was the second largest expenditure made by the UCREFRP behind habitat restoration. In-river removal, the primary threat reduction action taken by the UCREFRP and the SJRIP has been evaluated (Breton *et al.* 2014; Franssen *et al.* 2014; Zelasko *et al.* 2015; Pennock *et al.* 2018). Removal programs in the UCREFRP are being adjusted annually (i.e., level of effort, spatial allocation, target species, etc.) as appropriate.

Although efforts to reduce the number of smallmouth bass show potential for successful reduction (Breton *et al.* 2014), removal efforts may need to continue as long as source populations exist. Catch rates have declined in recent years, but vary depending on local environmental conditions; smallmouth bass continue to recruit in high numbers during low water years (U.S. Fish and Wildlife Service 2017). Efforts continue to suppress populations but are unlikely to eliminate populations without more effective and innovative solutions. Recent efforts have focused on the potential use of dramatic increases in flow or turbidity during smallmouth bass spawning periods, for reach-wide population effects. A spike in flow associated with a thunderstorm over the Yampa River watershed in 2015 prevented recruitment of an entire year class of smallmouth bass through larval displacement and nest abandonment by males (Bestgen *et al.* 2018).

Efforts to reduce and remove northern pike will also need to be expanded to positively impact the native fish community (Zelasko *et al.* 2015). Reducing in-river reproduction and source emigration as a means to successfully controlling populations has been recommended (Breton *et al.* 2014; Zelasko *et al.* 2015). In recent years, fyke nets have been deployed in tributary mouths during spawning seasons for northern pike, which has removed hundreds of pike with relatively little effort when compared to electrofishing. Catch rates have declined to just over 100 fish in that reach in 2017, indicating that new gill-netting techniques are also helping in backwaters and tributary mouths to decrease pike populations (C. T. Smith and Jones 2017).

UCREFRP has recently focused on the installation of escapement-prevention devices at upstream reservoirs, such as Elkhead, Rifle Gap, Highline Lake, Starvation, Ridgway, and Lake Nighthorse, and the eradication of illegally introduced populations of walleye and smallmouth bass, such as those at Paonia, Miramonte, and Red Fleet reservoirs. Annual surveys show a marked decrease in nonnative fishes below escapement devices, in some cases eliminating northern pike and smallmouth bass in downstream waters (Felt 2018). The Elkhead Screen was installed in 2016. After one year of operation, largemouth and smallmouth bass were found in both the spillway site and the stilling basin, but northern pike were not (A. Martinez *et al.* 2017). The screen is to be inspected annually, and fishing surveys will document the presence of fish behind the net and in spillway canals. To date, complete containment has not been obtained.

Over the past 3–5 years, walleye removal efforts in the Green and Colorado have not resulted in a decline in adult catch rates (Michaud *et al.* 2016). Efforts are currently ongoing to perform otolith microchemistry analyses to determine origin of walleye collected in the upper Colorado River subbasin (Michaud *et al.* 2016). Lake Powell is hypothesized to be a source, as populations of walleye and gizzard shad (a main food source) are expanding in the reservoir.

Currently, San Juan River nonnative-control efforts focus on removing channel catfish and common carp. Since 2011 more than 138,000 channel catfish and 800 common carp have been removed during SJRIP nonnative-control efforts (Duran *et al.* 2013; Gerig and Hines 2013; Duran 2014; Hines 2014; Hines 2015; Duran 2016; Hines 2016). In 2016, the SJRIP implemented a new control-treatment design to evaluate the effects of nonnative fish removal. A draft report indicates that current removal efforts are likely too low to cause measurable effects on catch per unit effort or population abundance, but are having measurable effects on the size structure of the population (Franssen *et al.* 2014; Duran 2016; Pennock *et al.* 2018).

Procedures for stocking nonnative fishes have been developed and agreements have been signed between the USFWS and the states of Colorado, Utah, and Wyoming for the Green River and upper Colorado River subbasins (U.S. Fish and Wildlife Service 2009b). These procedures identify the measures necessary to fully evaluate any species stocked into state waters and ensure that these species will not threaten native species. Similar efforts are underway in the San Juan River subbasin.

Fish harvest regulations (P. Martinez *et al.* 2014) have been updated in the states of Utah, Wyoming, and Colorado to limit abundance and encourage take of problematic nonnative species and prevent new introductions. For example, burbot *Lota lota*, walleye, northern pike, and smallmouth bass may not be returned to endangered fish habitat if captured in Utah or key portions of Wyoming, and they can be harvested in unlimited numbers in Colorado.

Anti-escapement devices, such as fish screens or curtains and even energy-dissipating “Bass-O-Matic” (Lake Nighthorse) devices (P. Martinez *et al.* 2014; Bark *et al.* 2014) have been installed at the outlet of six small public reservoirs in the UCRB to reduce the numbers of nonnative fishes that may enter habitat occupied by the various native fishes. The screens are monitored annually and have been shown to prevent escapement, often while fisheries transition to compatible species.

Over the past 15 years, nonnative fish management in the UCREFRP and the SJRIP has been adaptive and continually refined. Sustained nonnative fish management (mechanical removal, reservoir screens, incentive harvests, and use of compatible species) will be required to improve habitat for razorback sucker (Fischer 2018).

In the LCRB, the Long-Term Experimental and Management Plan EIS (U.S. Department of the Interior 2016), and the U.S National Park Service (NPS) Comprehensive Fisheries Management Plan (U.S. Department of the Interior 2013) provide criteria for triggering mechanical removal of nonnative fishes and outline nonnative fish management strategies to employ within the Grand Canyon.

The LCR MSCP helps maintain backwater habitats for razorback sucker as predator-free environments (LCR MSCP 2004). Collecting wild larvae, rearing early life-stage razorback sucker in predator-free settings, and eventually repatriating these fish into locations below Lake Mead are key strategies to help mitigate the effects of predation and competition in the LCRB as well as impacts from river regulation. Brown and rainbow trout are being removed from several locations within Grand Canyon and Glen Canyon National Recreation Area. Nonnative fish removal is not conducted within the remainder of the LCRB due to overall feasibility, however, stocking of disconnected backwaters is being implemented to provide refuge habitats free of nonnative fishes and their detrimental effects on razorback sucker.

Table 3. Summary of nonnative removal in each subbasin

Subbasin	Species Targeted for Removal	Species Removed if Encountered
Green	smallmouth bass, walleye, northern pike	bluegill, black crappie, largemouth bass, yellow perch, tiger muskie, wiper, white crappie, white sucker, burbot, grass carp
Colorado	smallmouth bass, walleye, northern pike	bluegill, black crappie, largemouth bass, yellow perch, tiger muskie, wiper, white crappie, white sucker, burbot, grass carp
San Juan	channel catfish, common carp	All nonnative species
Lake Powell	None	None
Grand Canyon	brown trout, rainbow trout	None
Lake Mead	None	None
Lake Mohave	None	None
Lake Havasu	None	None
Colo. River below Parker Dam	None	None

4.2.4 Research/Monitoring

The programs conduct research and monitoring to generate information on abundance, reproduction, growth, and survival of endangered fish in the wild. Data management systems serve as repositories and analytical tools for the collected information. Data are used to evaluate and adjust management actions and recovery strategies through adaptive management.

In the Green River and upper Colorado River system, UCREFRP estimates adult abundance and survival rates of stocked fish based on data collected during Colorado pikeminnow sampling (Projects 127 and 128), nonnative fish removal passes and location-based monitoring (e.g. Project 163). Presence and density of larval fish are annually documented (Projects 160 and 163). Effectiveness of floodplain wetland management and nonnative removal efforts are studied and documented in Habitat Restoration and Nonnative Fish program elements respectfully. All projects have annual reports and final reports posted on the program's website (www.coloradoriverrecovery.org).

In the San Juan River, the SJRIP uses a standardized fish monitoring plan and protocols developed in 2000 and updated in 2006 that describe the sampling design and strategies to be used in monitoring Colorado pikeminnow and razorback sucker and their habitat as part of the entire fish community (San Juan River Basin Recovery Implementation Program 2016). The monitoring program also provides a basis of new information to be used to update management and conservation activities as part of the Program's adaptive management process. Other monitoring documents fish communities and ecosystem response, habitat availability and restoration efforts, and augmentation effectiveness (San Juan River Basin Recovery Implementation Program 2016). SJRIP also monitors the San Juan arm of Lake Powell.

LCR MSCP conducts research on razorback sucker and its habitats to (1) inform selection and application of conservation techniques, (2) document successful implementation of conservation measures, and (3) develop alternatives to conservation actions that prove ineffective through the Adaptive Management Program (AMP). This helps researchers quantify existing knowledge, identify data gaps, and design and implement species research to fill these data gaps. Conceptual ecological models (CEMs) have been developed for razorback sucker to assist in further identifying these data gaps and help to prioritize and redefine research topics (Lower Colorado River Multi-species Conservation Program 2018).

To support monitoring efforts, all stocked fish are implanted with a passive integrated transponder (PIT) tag that allows each fish to be tracked back to its original stocking or capture event. Remote PIT-tag antennas are distributed throughout the Colorado River basin and routinely detect PIT-tagged razorback sucker. The data are stored and analyzed with all other monitoring data in comprehensive databases managed by the programs.

4.2.5 Augmentation

Hatchery broodstocks and refuge populations of razorback sucker are maintained in various federal and state facilities. Hatchery-produced razorback sucker are being stocked routinely in the UCRB and LCRB. In the LCRB, wild-produced Lake Mohave larvae are collected annually

and are subsequently reared in hatcheries or other protected habitats and repatriated at adult sizes to prevent predation of juvenile fish. The distribution of adult fish from hatchery-raised or collected wild-produced larvae are both considered stocking and augmentation efforts. All fish are stocked at average lengths of 300 mm or more.

The UCREFRP has two facilities dedicated to the production of razorback sucker that each produce and distribute 6,000 razorback sucker averaging 350 mm or greater. The Grand Junction Endangered Fish Facility in Grand Junction, Colorado stocks razorback sucker in the Colorado and Gunnison Rivers and the Ouray National Fish Hatchery in Vernal, Utah stocks razorback sucker into the Green River.

The SJRIP stocks 11,400 razorback sucker annually. Southwestern Native Aquatic Resources and Recovery Center (SNARRC) maintains a captive broodstock population large enough to produce razorback sucker for annual stocking, which are then grown at Navajo Agricultural Products Industry (NAPI) ponds in New Mexico and Horsethief Canyon Native Fish Facility (HCNFF) in Grand Junction, Colorado. A broodstock of 1,176 adult fish of Lake Mohave origin is currently being maintained and managed as identified in SNARRC's RBS Genetics Management and Captive Propagation Plan (2004).

The LCR MSCP Fish Augmentation Program has committed to stocking 660,000 subadult razorback sucker into the Colorado River system over a 50-year term. Between 2005 and 2017, 180,727 were stocked into Reaches 3-5 (Lower Colorado River Multi-species Conservation Program 2018). The broodstock for this effort was developed from larvae collected from Lake Mohave and reared at the Willow Beach National Fish Hatchery in Arizona and the Lake Mead Fish Hatchery in Nevada. Additional fish rearing capacity is available at the Achii Hanyo Native Fish Rearing Facility (Arizona), the Overton Wildlife Management Area (Nevada), and the Bubbling Ponds Fish Hatchery (Arizona) all of which have varying production goals. A second broodstock is maintained at SNARRC (Lower Colorado River Multi-species Conservation Program 2018).

5 CURRENT RESOURCE AND SPECIES' CONDITION

In this section, current condition was evaluated for eight populations, four in each of the upper and lower basins (Figure 10). The four upper basin populations include the Green River subbasin, the Colorado River subbasin, the San Juan River subbasin and Lake Powell. Lower basin populations include Lake Mead (including the Grand Canyon), Lake Mohave, the Colorado River between Davis and Parker dams (Lake Havasu) and the Colorado River below Parker dam. Stocking efforts continue in other areas, including the Verde River, but survival is low, making these populations difficult to assess.

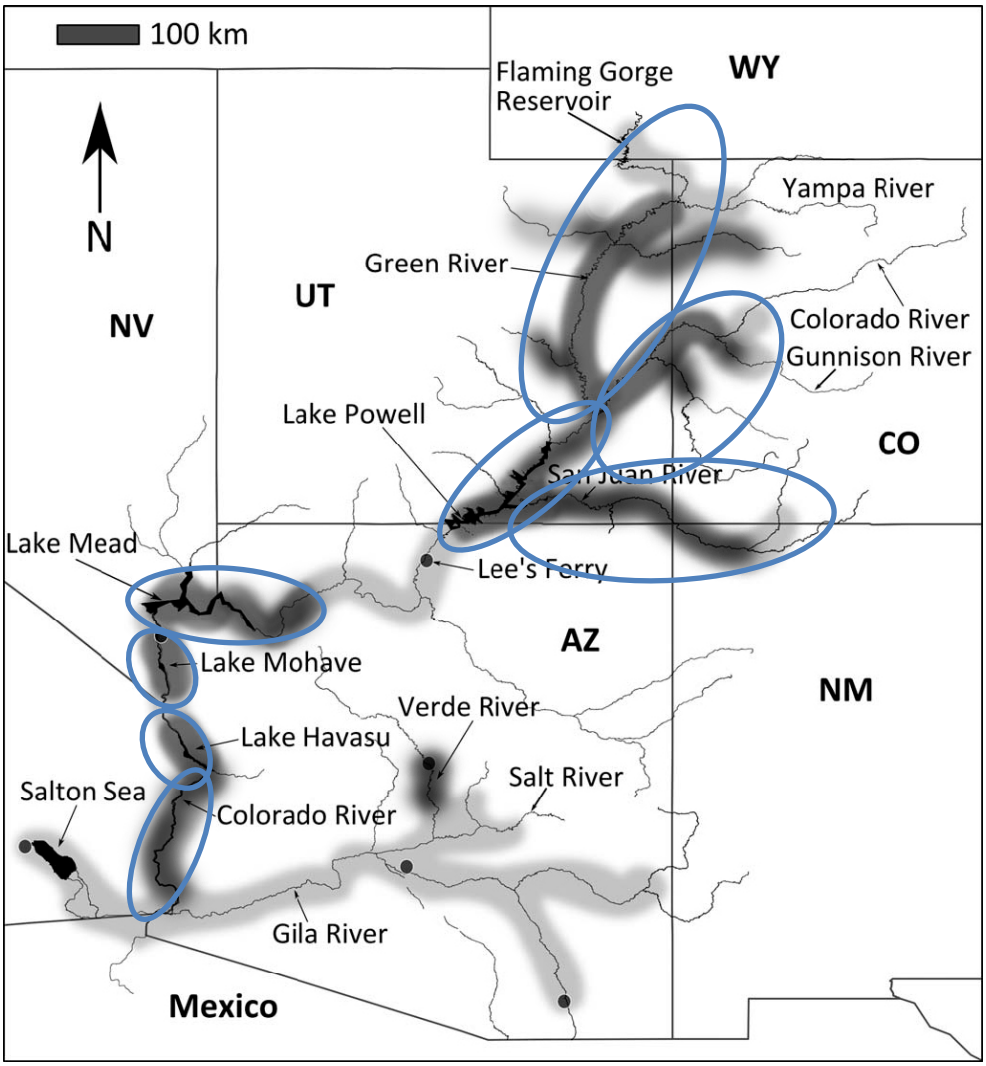


Figure 10. Historical (light gray highlight) and current (dark gray highlight) distribution of the razorback sucker in the Colorado River basin with assessed populations circled (blue).

For each population, we evaluated each of the physical species needs and the demographic response to those needs. We used four condition categories for each species need: high, medium, low or extirpated condition representing a continuum from high (best) to extirpated (worst) condition. Definitions of species needs in each category were developed to provide consistency (Table 4 and Table 5) during assessment of current and future conditions.

Table 4. Condition category table for physical needs of razorback sucker. Each cell below defines the condition under which a category is given for each need.

	Physical Needs					
	Complex Habitat					
	Habitat	Nonnative presence in habitat	Water quality/Temperature	Variable flow (lotic only)	Adequate food	Range & connectivity
High	Spawning habitat is available throughout the system in close proximity to appropriate larval habitat. Nursery areas are present throughout the system, and accessible to larvae. Cover is available to provide protection in the form of turbidity and/or vegetation. Adult habitat present including open stretches of water, deep pools, low-gradient runs and long-lengths of open river in lotic systems.	Nonnative predators and competitors are rare.	Water temperatures within thermal preferences (between 15 - 25 C) and follow a natural pattern of being lower during spring runoff and warming during summer months. Chronic water quality impairments are absent.	Variation in flow releases or weather patterns provide inter- and intra-annual variability. Natural or regulated flows provide seasonally high flows (e.g., peak discharge from melting mountain snow), promote regular inundation of floodplain depressions and side-channels when larvae are present, sediment sorting to clean spawning beds and the formation of deep pools and side channels, base flows are sufficient throughout the summer.	High productivity occurring throughout the system, larvae have access to warm, food rich environments in most years immediately following emergence.	No impediments or barriers to migration, allowing adults to migrate between river systems and far up rivers and tributaries during the spawning season.
Medium	Spawning habitat is available. Nursery areas are present and accessible to a significant proportion of larvae. Cover is available to provide protection in the form of turbidity and/or vegetation. Presence of adult habitat throughout the system.	Nonnative competition is present, but nonnative predators are uncommon or controlled.	Temperatures follow seasonal patterns, coupled with some depression from dam releases (some periods between 10-15 C during growing season). Chronic water quality concerns such as mercury or selenium or emerging contaminants are present, but not considered a major factor influencing population size or health. Growth and reproduction rates are not impeded.	Natural and regulated flows provide some of the benefits of natural seasonal fluctuations, including periodic connection of some floodplain environments in most years when larvae are present; moderate amounts of sediment sorting and channel complexity occur annually. Some flow variation occurs year to year.	Moderate productivity or impaired water quality that limits the abundance of food items during the larval, juvenile, and/or adult stage.	Barriers are present, but conditions are sufficient in the limited area to provide adequate habitat/conditions for all life stages. Movement is limited between populations.
Low	Spawning habitat is available. Nursery habitats exist in the system but are not available to most larvae. The population is restricted to river reaches and/or lentic habitats that are usually disconnected from seasonally inundated floodplains or coves, and primary cover available is turbidity. Presence of adult habitat throughout the system, but channelization reducing depth and increasing velocities of pool environment.	Nonnative competitors and predators are common throughout the system.	Consistent temperatures between 10-15 C, sufficient to reduce growth. Mercury, selenium or emerging contaminant loading present in some areas throughout the system, reducing reproductive success in those locations.	Regulated flows provide adequate volume to the system, seasonal pattern is generally maintained, but is consistent from year to year. Base flows are present, but low, supporting development of nonnative populations.	Reductions in productivity sufficient to reduce body condition of fish.	Barriers restrict migration sufficiently to form an isolated population restricted to an area too small to support completion of all life stages, possibly preventing access to historic spawning bars or appropriate juvenile habitat.
Extirpated	Spawning habitat compromised by siltation and nursery habitats are infrequent or inaccessible. Slow velocity habitat for adults removed through channel narrowing and simplification, or inaccessible because of lack of connection. Routine low-flow conditions reduce habitat available to adults.	All habitat dominated by nonnative predation and/or competition.	Temperatures consistently depressed below 10 C throughout the year, which precludes development and survival of early life-stages. High levels of water quality contaminants (e.g. heavy metals, emerging contaminants or spills) creating toxic conditions.	Highly regulated flows disconnect the floodplain from the main channel and create a simplified, ditch-like channel morphology reinforced by root masses of invasive trees and shrubs (e.g., Russian olive and tamarisk). Variable flows are rare, if present, supporting growth of nonnative fish populations.	Severe reduction in productivity from reduced temperatures, increased siltation or impaired water quality resulting in reduced survival of one or more life stage.	Upstream and downstream barriers to migration preclude access to suitable habitat(s) to meet larval, juvenile, or adult requirements, which could include floodplain wetlands and backwaters or historic spawning bars. In some cases, the barrier could be a lack of sufficient flows to connect floodplain environments.

Table 5. Condition category table for razorback sucker demographics. Each cell below defines the condition under which a category is given for each need.

	Demographics					
	Adult population size (wild + stocked fish)	**Spawning and larval presence**	**Recruitment**	**Dependence on stocking**	**Genetic integrity**	**Population stability (wild recruited adults)**
High	Population is estimated at >5800 as outlined in 2002 recovery goals.	Spawning occurs annually at multiple spawning locations adjacent to appropriate larval habitat. Large cohorts of larvae are produced at multiple spawning sites on an annual basis.	Greater than 75% of juvenile year classes are present (3 of every four years show recruitment) OR Documented wild fish are abundant	Wild populations do not require supplemental stocking, stocking has ceased.	Genetic diversity is high, relatedness values are low, a high percentage of adults participate in reproduction annually and hybridization is low. N_e of 1000 indicating a level of maximum genetic variation.	Population is self-sustaining without stocking. Recruitment is occurring across many generations. OR Average lambda[3] equal to or greater than 1 over many years, if measured.
Medium	Population estimates are feasible with sufficient recaptures. Estimates are less than 5800 per population but greater than 500 adults.	Spawning occurs annually at multiple spawning locations. Larval presence documented throughout the system annually, in varying density levels.	40-75% of juvenile year classes are present OR Documented wild fish are common	Stocking present to compensate for a small adult recruitment gap. Wild recruitment occurring, but not at a rate sufficient to offset adult mortality.	Populations show less robust diversity than optimal populations, Ne 500-1000.	Wild population is documented and increasing but must be supplemented with stocked fish occasionally. OR Lambda varies, with values commonly <1, but recurring strong year classes with lambda >1, if measured
Low	Population estimates are feasible with sufficient recaptures to calculate an estimate but the estimate is low (~500 adults or less)	Low numbers of adult spawners and/or unfavorable environmental conditions (e.g. low temperature or contaminant presence) limits egg production, or larval survival. Larval presence documented at some locations, in low densities.	25% of year classes are present OR Documented wild fish are uncommon OR Untagged fish are found in rates higher than can be attributed to tag loss (10-25% untagged fish)*	Recent stocking is the primary source of individuals in the population, but stocked fish routinely survive (post-first year survival is high >65%).	Pronounced reduction in diversity and increase in relatedness, effects not managed through stocking. N_e of 50-500, sufficient to prevent inbreeding depression, but risks long-term genetic drift.	Wild adults are documented, but at levels too low to determine population trends. OR Wild population trends negative, natural recruitment not occurring at a level to off-set adult mortality, must be stocked regularly. OR Lambda almost always <1, if measured.
Extirpated	Individuals in population are too few to support population estimates.	Larval presence is not documented in the population.	Juveniles are rare, captures are inconsistent and/or Untagged adults are present at levels that could be attributed to tag loss (<10%)*	Stocking is needed to maintain species presence; high mortality of all age classes results in no species presence absent stocking efforts (e.g. Verde River)	Bottlenecks occurring in genetic variation because of high relatedness or high hybridization rates. Effects not managed through stocking efforts. N_e of 50 or less resulting in inbreeding depressions.	No wild adults have been documented and wild populations are assumed extirpated OR Wild populations have strongly negative growth rates, likely to result in extirpation. Lambda <1 for many sequential years, if measured.

*A rising number of untagged adults in a system may provide the first indicator that additional studies should be conducted to assess recruitment. Studies using similar species indicate that tag loss is <1% when adults are tagged (Ward and David 2006; Hooley-Underwood *et al.* 2017) and that rates of tag loss can be higher in small juvenile fish (12.5-30%) (Ward *et al.* 2015).

[3] The intrinsic rate of population growth.

5.1 Upper Colorado River Basin Resource Conditions

5.1.1 Complex Lotic and/or Lentic Habitat (affected by presence of nonnative fish)

Depending on life stage and location, the razorback sucker uses the suite of available habitats in reservoirs, main channels, backwaters, and floodplain wetlands. Complex habitats including seasonally-connected backwaters, floodplains, and low-velocity slackwaters have diminished due to water development and anthropogenic activities over the last century. However, ample spawning and adult habitat are available throughout the upper basin.

In the Green River, multiple spawning bars are present and commonly used on an annual basis from the Yampa confluence downstream to Millard Canyon. Anecdotal evidence and detections on remote PIT antennas suggest that spawning in tributaries is likely widespread (e.g., Yampa, White, Price, San Rafael). The largest concentration of razorback sucker in the UCRB exists in low-gradient, flat-water reaches of the middle Green River between the Yampa River confluence (RM 570) and Sand Wash (RKM 345.6), including the lower few miles of the Duchesne River, and a recent expansion into the White River (Modde and Wick ; Tyus 1987; Tyus and Karp 1990a; Muth 1995; Muth *et al.* 1998; Muth *et al.* 2000; Bestgen *et al.* 2011; Bestgen *et al.* 2012; Webber *et al.* 2013; STReaMS 2016). This reach also contains the largest expanse of floodplain habitat and nursery habitat in the UCRB (Irving and Burdick 1995; Muth *et al.* 2000). The UCREFRP is currently working to expand access to habitat through both habitat improvement and flow recommendations. One of the most promising tools is the development and management of floodplain wetlands to provide predator-free environments and promote juvenile survival. In the spring, larval monitoring occurs in the river channel. Once larvae are present, flows are increased to increase floodplain connections, allowing the larvae to access the previously disconnected floodplain. The flow is screened to exclude large-bodied predators, but many species of larvae enter the wetland simultaneously. Water quality and quantity is monitored throughout the summer and supplemental water is added if necessary. Each fall, the wetlands are drained, returning native fish to the river and removing any nonnatives present.



Figure 11. Examples of complex habitat including floodplain habitat along the Green River (left) and Colorado River arm of Lake Powell (right) (images from Google Earth).

In the upper Colorado River subbasin, many studies point to the Grand Valley ('15' and '18 mile reaches' of the Colorado River[4]) as important spawning reaches for razorback sucker, as evidenced by ripe fish that are frequently found. The reaches contain numerous cobble bars, complex habitat and readily accessible off-channel ponds (e.g. Walter Walker SWA on the Colorado and the Escalante SWA on the Gunnison). Unfortunately, off-channel ponds are also often filled with large-bodied nonnative predators, making them less conducive for razorback sucker recruitment. In the Gunnison River, capture of ripe females in 2013, 2015 and 2017 indicate that spawning in that system may have occurred near Delta. Extensive cobble bars exist between Hartland Diversion Dam and Escalante SWA, providing spawning grounds upstream of the largest remaining piece of floodplain habitat in the Gunnison basin. Lower reaches of the Colorado River (between Moab and Lake Powell) provide instream habitats like backwaters, embayments, and flooded wash mouths, but which may be compromised by nonnative predators. The State of Utah is currently working to develop a floodplain wetland along the Colorado River near Moab to serve as predator free habitat for larval-juvenile razorback sucker. Adequate adult habitat exists, including deep pools, low-gradient runs and long-lengths of open river throughout the upper Colorado River subbasin.

In the San Juan River, cobble and gravel areas are present throughout the system, though barriers make some areas difficult to access. Currently, backwaters and complex habitats are declining and are low in abundance (Bliesner and Lamarra 2007; Bliesner *et al.* 2008; V. A. Lamarra and Lamarra 2013), but have been shown to increase during higher flow years (V. A. Lamarra and Lamarra 2018). Razorback Sucker spawning has been documented throughout the system with higher larval levels present in backwaters and embayments than in low velocity areas in the river (Farrington *et al.* 2018). Different sections of the river have differing capacities for nursery habitat to form; high discharges maximize formation of nursery habitats (V. A. Lamarra and Lamarra 2018). Side-channels provide seasonal habitat and are actively being restored by the SJRIP. Adequate adult habitat such as deep pools exist throughout the system. Several tributaries, including the Animas River and McElmo Creek in Utah are commonly used by native fish including razorback sucker, showing an increase in use of available habitat (STReaMS 2016, Schleicher 2016).

With the construction of Glen Canyon Dam and the creation of Lake Powell, vast expanses of inflow and lentic habitats were created that resemble historic floodplain and wetland habitat. Lake Powell inflow areas provide habitat for all life stages of razorback sucker, including shallow shorelines for spawning, cover for juvenile fish in inflow areas and deep pools for adults. Recent research documented razorback sucker use of the Colorado River and San Juan River arms of Lake Powell (Francis *et al.* 2013, 2015; USFWS unpublished data). Typically, inflow areas show higher turbidity than reservoir basins year-round, providing protection from nonnative predators (Albrecht *et al.* 2017). Substrate complexity that can be used for spawning and feeding is often found within these inflow areas. Large wood and vegetation transported from the river channel also provides unique, much needed structure at inflow areas. Other areas of the lake have not been studied; use by razorback sucker is unknown.

[4] The 15-Mile Reach is a river reach that extends from the confluence of the Gunnison River upstream 15 miles to the Grand Valley Irrigation Company Diversion Dam near Palisade, Colorado. The '18-Mile Reach' begins downstream of the Gunnison River confluence, flowing for 18 miles, still in the Grand Valley.

5.1.1.1 Presence of nonnative fish

In the UCRB, smallmouth bass, walleye, channel catfish, and northern pike are predatory nonnative fishes of greatest concern. Northern pike and smallmouth bass are established with high levels of recruitment occurring in certain reaches of the upper Colorado River basin, including the Yampa and Green rivers. Largemouth bass and walleye are primarily emigrants from reservoirs, with no known records of recruitment in riverine portions of the upper Colorado River System. Channel catfish occur throughout the UCRB, but are not considered piscivorous until they reach large adult sizes. Channel catfish may be problematic in the San Juan River.

The Green River and its tributaries support high densities of nonnative fishes that commonly prey on various sizes and life stages of razorback sucker. Three species, smallmouth bass, northern pike and walleye, are highly predaceous and can collectively eliminate or severely deplete entire year classes of razorback sucker. Smallmouth bass are established in the Yampa and Green Rivers and are actively removed by the UCREFRP. Smallmouth bass were rare in Yampa Canyon in 1997, but increased to 18% of the adult fish composition by 2004, concurrent with a decline in native fish composition (Modde and Haines 2005). In response to increasing nonnative fishes throughout the upper basin, the UCREFRP developed a rigorous nonnative fish management program targeting smallmouth bass, walleye and northern pike. Between 2013 and 2016, almost 50,000 smallmouth bass were removed from the Yampa River and an additional 43,000 were removed from the Green River during population monitoring and specific removal efforts (STReaMS 2016). High catch rates of smallmouth bass occurred in 2014 and 2015 after a strong year class developed during low-flow conditions in 2013 (U.S. Fish and Wildlife Service 2017). Northern pike have established populations in the Yampa and upper Green rivers, but are limited by warmer temperatures in lower reaches of the Green River. In 2004, over 800 northern pike were removed from the middle Yampa River (Hawkins 2004). Catch rates have since declined to just over 100 fish in that reach in 2017, indicating that new gill-netting techniques in backwaters and tributary mouths are decreasing populations (C. T. Smith and Jones 2017). Increasing numbers of walleye have been reported in the Green River since 2007 and in the upper Colorado River since 2010 (Michaud *et al.* 2016). Walleye are present in high-elevation reservoirs of Green River tributaries (e.g., Starvation Reservoir) and in Lake Powell, where they are increasing in abundance. Increasing numbers of gizzard shad and walleye in Cataract Canyon may be the result of upstream expansion of Lake Powell populations (Michaud *et al.* 2016).

After the creation of Lake Powell, introduction of non-native fish occurred quickly, now supporting populations of smallmouth bass, largemouth bass, striped bass, walleye, channel catfish, black crappie *Pomoxis nigromaculatus* and bluegill. Inflow areas commonly have inflow- or wind-driven turbidity and inundated terrestrial vegetation, which may offer protection from nonnative fish predation for larval, juvenile, and adult fish (Albrecht *et al.* 2017).

5.1.2 Suitable water temperature and quality

River temperatures in the immediate vicinity of Flaming Gorge Dam (FGD) on the Green River, Crystal Dam on the Gunnison River and Navajo Dam on the San Juan River are cooler than pre-dam averages due to releases from the reservoirs' hypolimnions (Holden 1999; Muth *et al.* 2000; U.S. Department of Interior 2006; McAda 2003; U.S. Department of the Interior 2012). Unlike at the other two dams, flow releases from FGD are managed for temperature at the confluence of

the Yampa, specifying that the temperatures in the Green and Yampa rivers must be close enough to prevent thermal shock. A temperature-control device installed on Flaming Gorge Dam in 1978 is used to warm downstream releases into the Green River and may allow for upstream expansion of native fishes into Lodore Canyon, Colorado. This warming could have provided more suitable conditions for native fish populations in Lodore and Whirlpool canyons.

In river reaches that are not in close proximity to dams, razorback sucker populations in the UCRB experience seasonal temperature variation similar to historic water temperatures. Water temperatures in the UCRB rarely exceed lethal maxima and predominantly remain within optimal range. Both arms of Lake Powell become warmer slightly later in the year, but they arguably exhibit a more natural temperature regime year-round than Lake Mead (Albrecht *et al.* 2017).

Water quality in the upper Colorado River basin is usually not a concern for razorback sucker. However, considerably more selenium is found in the Colorado River above the Green River confluence than in the Green and San Juan river basins. Selenium remediation has been implemented in the Gunnison River, and sources of selenium have been identified within the Green River (e.g., Stewart Lake) (U.S. Fish and Wildlife Service 2017) the specific effects of which are not currently known. Some evidence exists for negative impacts to reproductive biology of razorback sucker (Hamilton 1998; B. C. Osmundson *et al.* 2000). Fish consumption advisories are in place for mercury concentrations in various species in many upper basin waterbodies, including the Desolation-Gray reach of the Green River, Lake Powell, and Elkhead, Ridgway, Rifle Gap and Navajo reservoirs.

5.1.3 Variable Flow Regime

In general, river regulation in the UCRB has caused reductions in peak flows and increases in base flows when compared to pre-dam averages. This is especially evident in the Green (Figure 12), Gunnison, Colorado, and San Juan rivers. The construction of Flaming Gorge Reservoir in 1962 as well as smaller diversions throughout the Green River basin impacted flows and sediment transport; peak flows were reduced, base flows were modified, and sediment transport was reduced.

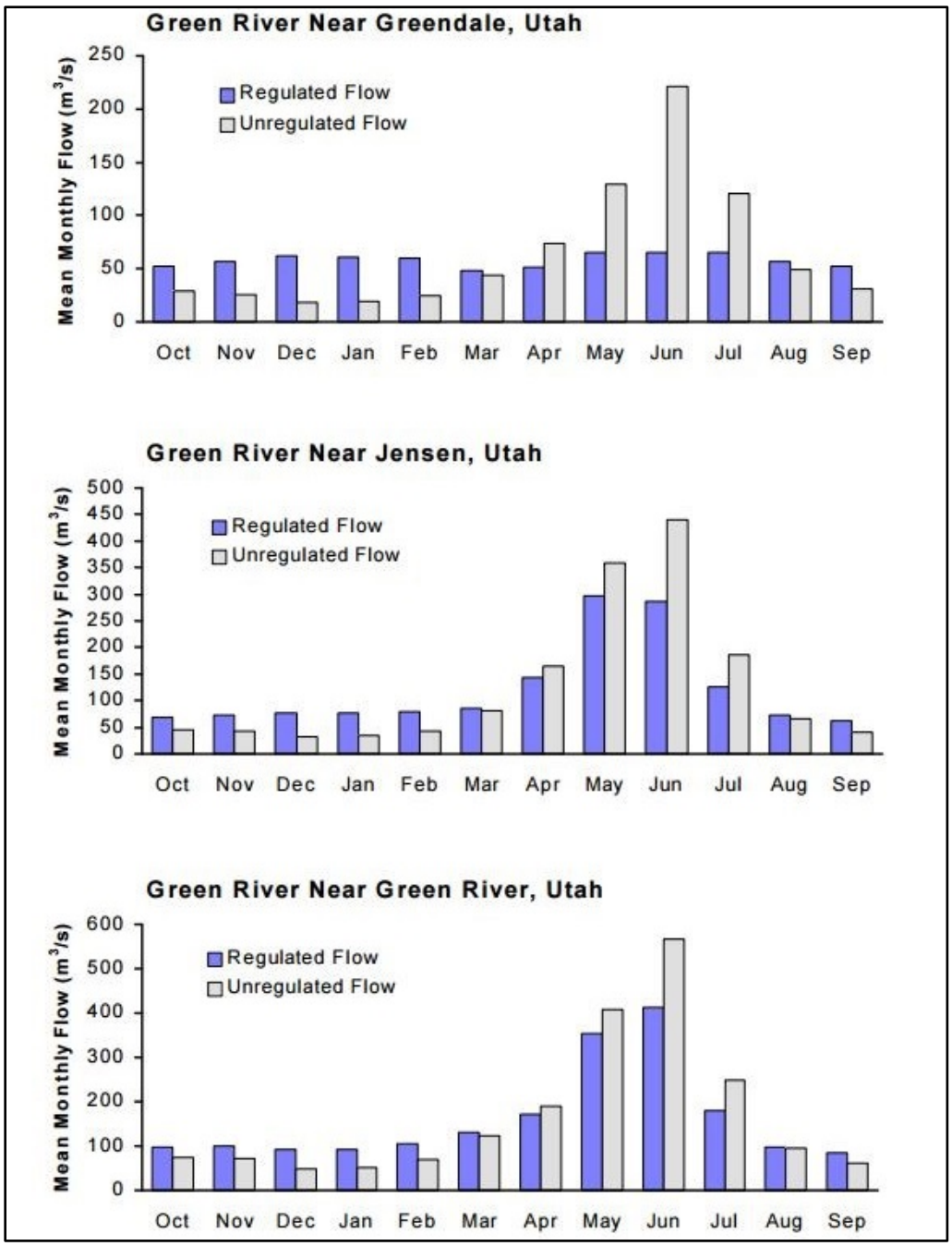


Figure 12. Average monthly flows as recorded at three locations on the Green River from 1963-1996 depicting varying levels of regulation: (top) immediately downstream of Flaming Gorge Dam (i.e., most regulated river reach) at the near Greendale, Utah, gage (Station Number 09234500); (middle) downstream of the confluence with the unregulated Yampa River (i.e., moderately regulated reach) at the Jensen, Utah, gage (Station Number 09261000); (bottom) downstream of additional tributary inputs (White, Duchesne, Price rivers) (i.e., least regulated reach) at Green River, Utah (Station Number 09315000) (reproduced from Muth *et al.* 2000).

High spring flows are required to reconnect backwaters and floodplains, which provide low-velocity nursery habitat for razorback sucker larvae. The UCREFRP has been coordinating with Reclamation to manage spring flows to provide these important floodplain connections on the:

1) Green River since 2006 (Muth *et al.* 2000; U.S. Department of Interior 2006); 2) Colorado River since 1999 (D. B. Osmundson *et al.* 1995; U.S. Fish and Wildlife Service 1999) and 3) Gunnison River since about 2010 (McAda 2003; U.S. Department of the Interior 2012).
A synthesis of larval razorback sucker captures (1992–2009) from the Green River (Bestgen *et al.* 2011) indicated that spring flow management at Flaming Gorge Dam could be better refined by timing floodplain connection releases to coincide with real-time captures of larval razorback sucker. A Larval Trigger Study Plan (LTSP) was developed to test this hypothesis (LaGory *et al.* 2012). Since 2012, LTSP releases have been coordinated with razorback sucker sampling (Figure 13). Current flow recommendations contain: 1) provisions for spring peak flow timing to enhance entrainment of larvae in floodplain wetlands; 2) peak flow magnitude / duration / frequency guidelines for channel maintenance and modification and 3) provisions to vary the base flow period (July - March of each year) by 25-40% above or below target values for each hydrologic category, which provides for intra-annual variability (Muth *et al.* 2000).

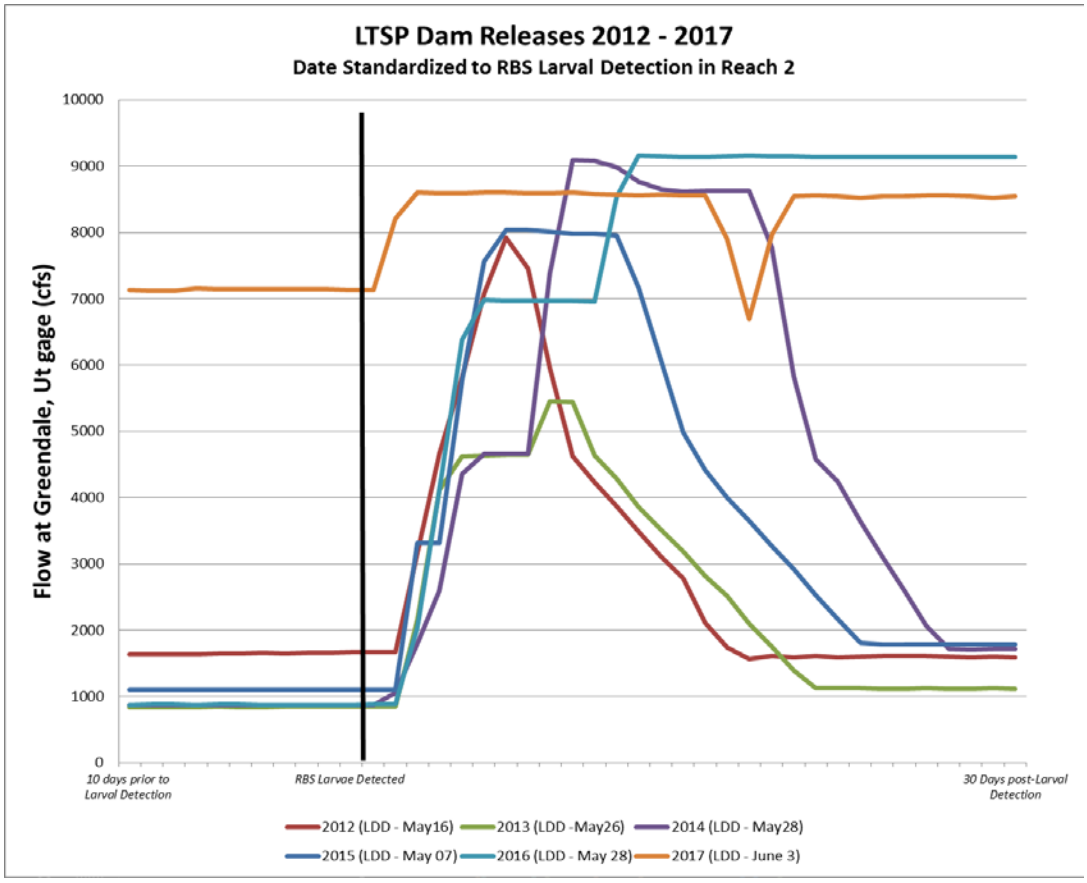


Figure 13. Reclamation's spring Larval Trigger Study Plan releases from Flaming Gorge Dam, 2012–2017, as measured at the US Geological Survey (USGS) near Greendale, Utah, gage (Station Number 09234500). The chronology of annual hydrographs has been standardized to first larval detection date (LDD). Actual annual LDDs are identified in the legend. Reach 2 is from the confluence with the Yampa River to the confluence with the White River.

The dam releases depicted in Figure 13, coinciding with emergence of larval razorback, have transported these larvae into at least one Green River floodplain study site every year and into multiple floodplain study sites in 2014 and 2015 (Schelly and Breen 2015; Jones *et al.* 2015).

Continued long-term commitment to flow management and LTSP will be necessary to maintain floodplain habitat connectivity that results from this management.

The Gunnison River contributes approximately 40% of the water in the Colorado River at the Colorado/Utah state line (McAda 2003). Water development has reduced the quantity of water in both the Colorado River mainstem as well as in the Gunnison River. Flow recommendations were developed to provide habitat and environmental cues for spawning, and include low velocity habitats for adult staging during runoff, floodplain inundations, in-channel habitat restoration and maintenance and providing base flows to promote growth and survival of young fish during summer, autumn and winter (McAda 2003). In the upper Colorado River mainstem, Coordinated Reservoir Operations (CROS) is an ongoing program implemented by UCREFRP to coordinate bypasses of reservoir inflows to enhance spring flows and improve habitat in the '15-mile reach' which flows through Grand Junction, Colorado upstream of the confluence with the Gunnison River. During the past 26 years, flows have exceeded 'wet' year targets at their desired frequencies, but have fallen short in lower-flow years (Anderson *in prep*, Figure 14). For the Gunnison River, a Programmatic Biological Opinion (PBO) provided consultation on water projects, resulting in a change in operations in the Aspinall Units to provide peak flows in coordination with the peak flow of the North Fork of the Gunnison (U.S. Fish and Wildlife Service 2009a). Operations under the Aspinall PBO are also intended to be beneficial to endangered fish communities in the Colorado River below the confluence of the Gunnison River.

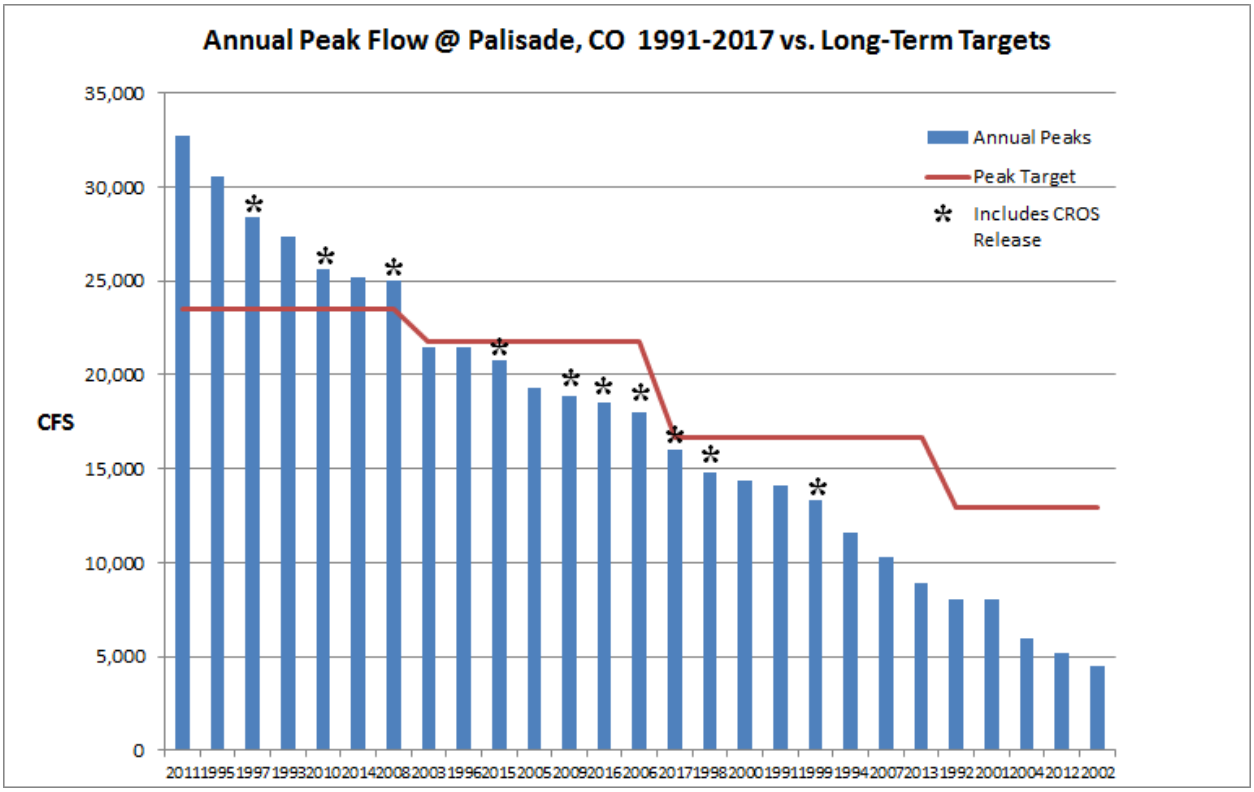


Figure 14. Annual peak flows at the top of the '15-mile reach' including augmented flow from CROS releases documented by flows at the USGS gauge on the Colorado River near Cameo, Colorado (Station No. 09095500). The red line illustrates the recommended frequency of peak flows exceeding particular magnitudes over a 27-year period. Figure from 15-mile Reach Programmatic Biological Opinion review (Anderson, *In prep*).

Navajo Reservoir Dam was constructed on the San Juan River in 1962 just south of the Colorado border in New Mexico to store flows from the San Juan, Los Pinos, and Piedra rivers. The San Juan River is similar to the Green and Colorado Rivers, in that they are large rivers with high spring flows and low base flows with off-peak variation provided by precipitation storm events (Holden 1999). Prior to construction of the Navajo Reservoir Dam, the annual average daily peak flows of the San Juan River were 8,230 cubic feet per second (cfs), which decreased to 2,725 cfs after the dam was implemented (Lamarra and Lamarra 2016). Flow recommendations were developed for operation of Navajo Dam in 1999, which were designed to mimic the natural hydrograph with intra- and inter-annual variability (Holden 1999). Since implementation, flows increased 47% to an annual average daily peak flow of 3,900 cfs (Lamarra and Lamarra 2016, Figure 15). Later studies indicate that the prescribed flows, in combination with establishment of nonnative vegetation, are not mimicking natural conditions as anticipated and are causing diminishment of complex habitats designed to support juvenile growth and maturation of native fish (Bliesner and Lamarra 2007; Bliesner *et al.* 2008; Lamarra and Lamarra 2013). The SJRIP implemented a new decision tree in 2016 to more frequently attain longer duration releases by determining attributes of current flows, developing a monitoring program to evaluate flow hypotheses and developing a structure for finalizing new flow recommendations and operations (San Juan River Basin Recovery Implementation Program 2016).

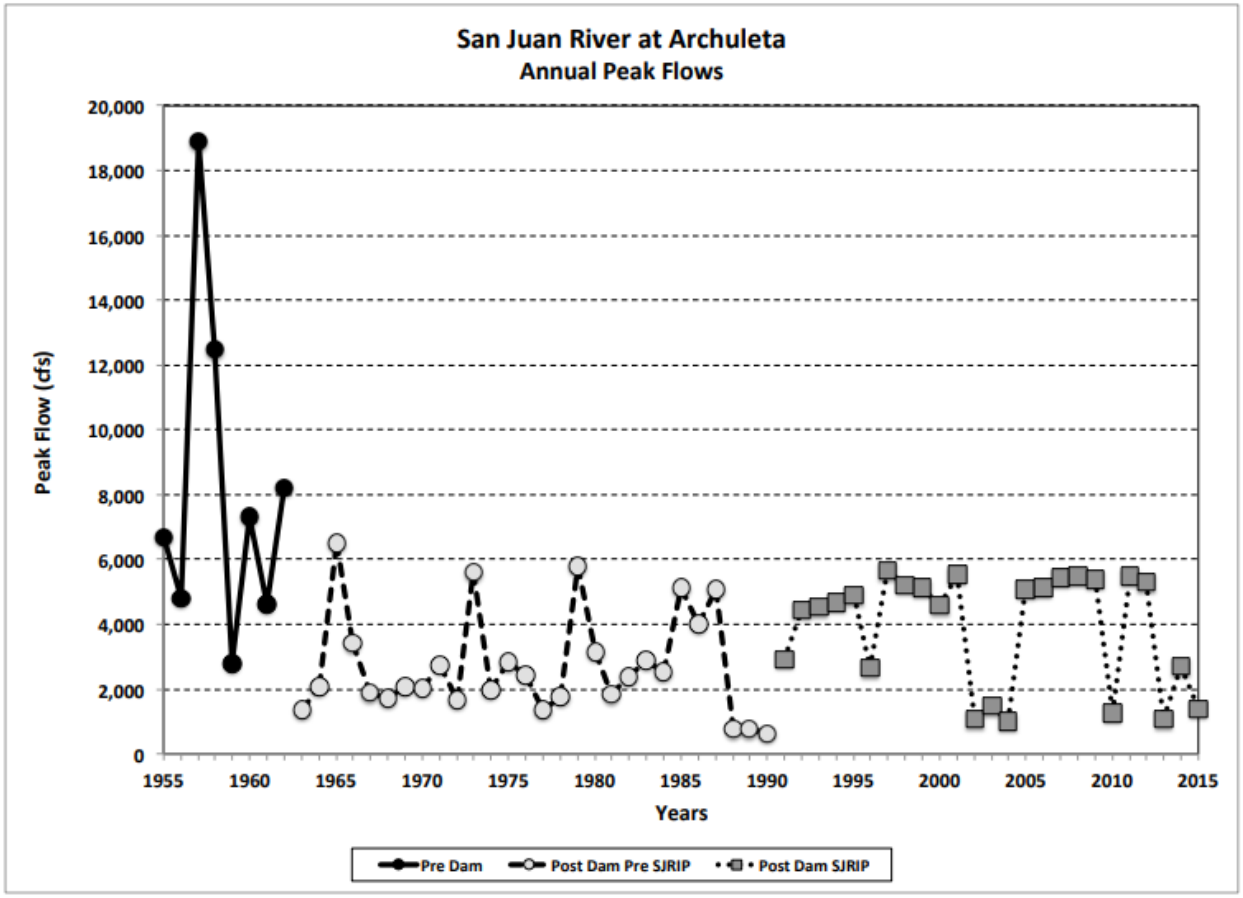


Figure 15. Annual maximum peak daily flows in the San Juan River from USGS gauge at Archuleta, San Juan River (Station No. 09355500), divided into three time periods: Pre-dam (1955-1962, black dots), post-dam, pre-SJRIP (1963-1991, light gray dots), and post-dam, post-SJRIP (1991-2015, gray squares). Figure from Lamarra and Lamarra 2016.

5.1.4 Food Supply

Food supply and availability for razorback sucker in the UCRB is not fully understood or described for all populations. The San Juan River macroinvertebrate community has been described as being of low diversity and high abundance below Navajo Dam (Holden *et al.* 1980; Dubey and Jacobi 1996; Brooks *et al.* 2000) with increased diversity and reduced abundance downstream (Sublette 1977; Holden *et al.* 1980; Brooks *et al.* 2000). Density and diversity of macroinvertebrates are also reduced in the San Juan River compared to the upper Colorado, Yampa, and Green rivers (Holden and Crist 1981; Rader and Ward 1988; Brooks *et al.* 2000; Miller and Lamarra 2006). While macroinvertebrate communities in the Yampa and Green rivers typically display increasing abundance from spring to fall (Holden and Crist 1981), the opposite was described in the San Juan River (Brooks *et al.* 2000). Although the study was not specific to razorback sucker food items, Rader and Ward (1988) found that macroinvertebrate taxa were reduced under regulated flows on the Colorado River downstream of Granby and Shadow Mountain reservoirs, and taxa abundance was higher compared with other regulated streams in the Rocky Mountains. As noted above, connection to floodplain wetlands is essential to provide larvae with protection to survive their first summer. Floodplain wetlands are usually more productive and warmer than main channel habitats during spring and early summer, which allows entrained larvae to grow substantially (Bestgen *et al.* 2011; LaGory *et al.* 2012).

5.1.5 Range and Connectivity

Razorback sucker exhibit movement across hundreds of miles among UCRB riverine and reservoir habitats. While limited by major barriers such as Glen Canyon Dam and the waterfall on the San Juan arm of Lake Powell, this degree of movement is likely similar to historical conditions. Fish passage structures have been built across all remaining diversion structures in the Green and Colorado river subbasins. Work is continuing on the San Juan, but restrictions to movement remain. From 1981-2015, nearly 1,350 razorback sucker demonstrated movement from one river to another, while the majority of the almost 400,000 fish PIT tagged fish encountered in the system moved less than 10 miles (Figure 16). Many of these movements are tributary to mainstem and vice versa, but some were of a larger scale. For example, one razorback sucker stocked into the San Juan River was detected in the Green River two years later; three other razorback sucker stocked in the San Juan River were detected in the Colorado River near the Colorado/Utah state line (Francis *et al.* 2015; Durst and Francis 2016). Thus, connectivity between the San Juan River and Colorado River mainstem and tributaries exists to some degree through Lake Powell. This information suggests the potential for connectivity and a metapopulation framework for razorback sucker within the UCRB. The only large-scale barrier remaining in the UCRB is the San Juan waterfall, a natural barrier that is compromised when Lake Powell is full, which is becoming less common as Lake Powell levels drop. Glen Canyon Dam does still separate the UCRB from the LCRB, preventing inter-basin movement.

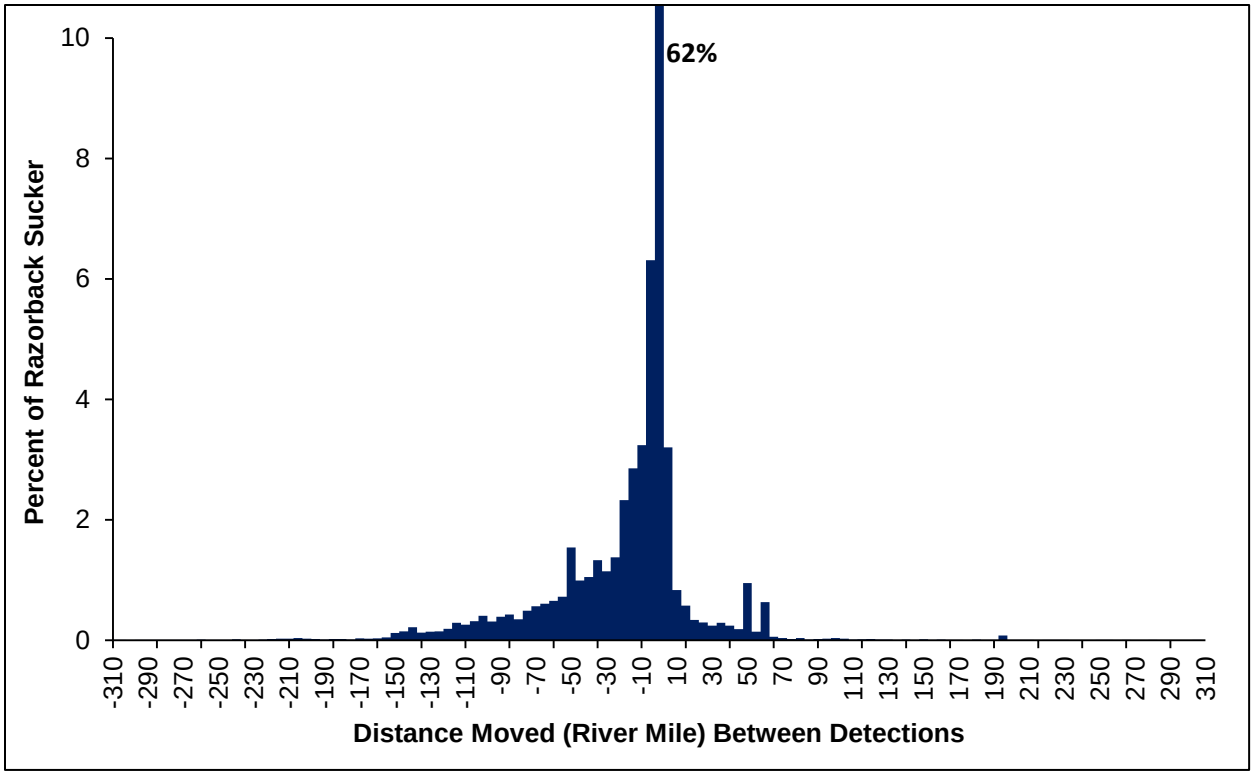


Figure 16. Movement of razorback sucker between capture and resighting from 1981 to 2015 displayed as a proportion of passive integrated transponder (PIT)-tagged fish (from STReaMS 2016).

5.1.6 Summary of Upper Basin Resource Conditions

Table 6. Summary of upper basin physical resources current condition for razorback sucker (high condition is represented by green, medium condition by yellow, low condition by orange and extirpated condition by red). The gray box around Lake Powell is meant to indicate a lack of scientific data in comparison with other upper basin populations.

	Physical Needs					
	Complex lotic/lentic habitat					
	Habitat	**Nonnative presence in habitat**	**Water quality/Temperature**	**Variable flow (lotic only)**	**Adequate food**	**Range & connectivity**
Green River Subbasin (plus inflow areas of Lake Powell)	• Multiple spawning bars are present and commonly used in Green River mainstem and tributaries. • Floodplain wetlands are available for use as nursery habitats in the Middle Green River where high levels of spawning activity occurs • Habitat for juveniles is present in the lower Green River in the form of backwaters, embayments and wash mouths, but are frequently compromised by nonnative predators • UCREFRP is actively trying to manage wetlands to provide sheltered, larval rearing habitat with varying results based on environmental conditions • Adequate adult habitat exists; including deep pools, low-gradient runs and long-lengths of open river, and adults have access to Lake Powell	• Northern pike are actively recruiting and abundant in the Yampa, common in the Upper Green and present in the mainstem downstream and in other tributaries. • Smallmouth bass are common above Green River, UT, with spawning and successfully recruiting populations • Walleye have become more common since 2010 • Channel catfish and small nonnative cyprinids are abundant in low velocity areas	• Water quality is thought to be sufficient to support all life stages • Water temperatures are artificially colder directly below FGD, but typically warm quickly; flows are managed to meet temperature criteria at the confluence with the Yampa River • The effects of high selenium concentrations remain unknown, but are currently under investigation • Floodplain wetlands may be more prone to contamination from selenium and mercury and are critical to recruitment in the basin • Other water quality concerns and their effects on reproduction have not been evaluated (i.e. other heavy metals, endocrine disruptors, hydrocarbons)	• Peak flows have been reduced since the construction of FGD, coupled with modified base flows • Flow recommendations provide intra- and inter-annual flow variability to meet a range of razorback sucker life history-specific needs • New flow recommendations are in progress for the White River. • The Yampa River is largely unregulated and often provides a significant volume of the spring peak flow and intra-annual variability due to precipitation events outside the spring peak period	• Adequate food is present for adults • Floodplain wetlands provide significantly greater food and temperature resources to larval RBS than the main channel environment, but nonnative predators and competitors are frequently abundant	• Range is seasonally limited by cold temperatures for a short distance below Flaming Gorge Dam • Fish migrate throughout the upper basin system including the Yampa and White Rivers (upstream to Taylor Draw Dam) and through the Colorado, Dolores, Gunnison and San Juan rivers and Lake Powell • A fish passage was recently constructed at the Tusher Wash Diversion, making the entire Green River subbasin accessible to endangered fish at all times of the year
Colorado River Subbasin (plus inflow areas of Lake Powell)	• Spawning bars are present in the mainstem Colorado as well as tributaries like the Dolores and Gunnison • UCREFRP has developed gravel pits along the river to provide age-1 and juvenile habitat, but many are deep, cut off from the river, and full of nonnative fishes • One wetland is currently in development and will be managed similarly to those in the Green • Lower reaches provide instream habitats like backwaters, embayments, and flooded wash mouths, which may be compromised by nonnative predators • Adequate adult habitat exists; including deep pools, low-gradient runs and long-lengths of open river and adults have access to Lake Powell	• Northern pike are present in floodplain gravel pits and are actively removed, but rare in the river itself • Smallmouth bass are widely distributed, but at lower densities than in the Green • Walleye catches have increased in recent years, with large numbers captured 2013-2015 • Channel catfish and small nonnative cyprinids are abundant in low velocity areas	• Water quality is thought to be sufficient to support all life stages • The effects of high selenium concentrations on reproductive success remain unknown, but are currently under investigation • Other water quality concerns have not been evaluated (i.e. mercury, other heavy metals, endocrine disruptors, hydrocarbons) • Temperatures in the Colorado seem well within tolerance levels, temperatures in the Gunnison are depressed because of dams	• Peak flows have been reduced and base flows modified following the completion of multiple upstream dams. • Active management prioritizes water through the '15-mile Reach' • Flow recommendations seek peak flow magnitude/duration/frequency guidelines for channel maintenance and provisions for minimum and base flow; targets have been met in most years (2012 Aspinall ROD and CROS)	• Adequate food is present for adults • Floodplain wetlands provide significantly greater food and temperature resources to larval RBS than the main channel environment, but nonnative predators and competitors are frequently abundant • Uncertainty remains as to whether or not a lack of appropriate food items is preventing recruitment in the river	• Range is seasonally limited by cold temperatures for a short distance below Aspinall Units • Fish migrate throughout the system including the Dolores and Gunnison rivers and through the Green and San Juan rivers and Lake Powell • Construction of fish passages have reconnected habitats that were previously blocked by diversion structures. No permanent barriers remain in razorback sucker habitat in the Colorado subbasin.

	Physical Needs					
	Complex lotic/lentic habitat					
	Habitat	**Nonnative presence in habitat**	**Water quality/Temperature**	**Variable flow (lotic only)**	**Adequate food**	**Range & connectivity**
San Juan River Subbasin (plus inflow areas of Lake Powell)	• Spawning areas are present throughout the system in varying conditions • Low abundance of backwaters in the river driven by higher gradient • Side-channels provide seasonal habitat and further restoration work is planned to increase quantity • Adequate adult habitat exists, including deep pools	• Channel catfish are well established, growing to large sizes which are piscivorous, but are not thought to have the same effect as other nonnative predators • Small nonnative cyprinids are abundant in low velocity areas	• Water quality is sufficient to support all life stages • The effects of high selenium and mercury concentrations on reproduction are in dispute, but are currently under investigation • Water temperatures support all life stages, but are artificially depressed below Navajo dam • Other water quality concerns have not been evaluated (i.e. mercury, other heavy metals, endocrine disruptors, hydrocarbons)	• Navajo Dam limits flow variability; reducing peak flows, modifying base flows and rarely allowing high flow events • Dam does provide protection against extreme low flows • In 2016, a new agreement was developed to increase frequency of releases and evaluate elevated baseflows	• Adequate food is present for adults • Uncertainty remains as to whether or not a lack of appropriate food items is preventing recruitment, and is complicated by a heavy nonnative fish presence in all juvenile habitat	• Range is seasonally limited by cold temperatures for a short distance below Navajo Dam • SJR (Piute Farms) waterfall prevents movement of fish between San Juan Arm of Lake Powell and San Juan River, but fish can pass if Lake Powell water levels are high enough • Numerous in-stream barriers persist in both the San Juan and Animas rivers, despite attempts to modify them for fish passage • Few fish present above PNM Weir (RM 166.7) and movement upstream through fish passage is limited
Lake Powell (including inflow areas and the lake proper)	• Clean talus, cobble and gravel areas used for spawning are present throughout the system • Sufficient turbidity likely exists at the river/lake interface inflow areas, providing cover for fish on both river arms. • Inflow areas could be receiving larvae from the riverine systems and may provide the habitat needed to recruit • Significant numbers of stocked razorback sucker migrate to Lake Powell, potentially indicating high quality adult habitat	• Nonnative predators are common in the lake and managed as sportfish • Small nonnative cyprinids are abundant in low velocity areas	• Water quality is sufficient to support all life stages • Other water quality concerns have not been evaluated (i.e. other heavy metals, endocrine disruptors, hydrocarbons), but are likely comparable to other systems both up and downstream	• Variable flow not applicable in Lake Powell, but annual filling and draining cycles likely create high-quality shelter for larval and juvenile fish during the spring-peak • Certain lake levels expose more near-shore habitat which can be advantageous to razorback sucker	• Abundant food is present in the lake habitat, resulting in high body condition factors	• Fish migrate around the lake without barriers • Fish movement among Lake Powell, the San Juan, and the Green and Colorado subbasins have been documented • The SJR (Piute Farms) waterfall does block connectivity (and nonnative fish intrusion), a phenomenon which could also conceivably occur on the Colorado if lake levels drop far enough

5.2 Lower Colorado River Basin Resource Conditions

5.2.1 Complex Lotic and/or Lentic Habitat

With three large mainstem reservoirs (Lakes Mead, Mohave, and Havasu) from Glen Canyon Dam downstream to the Gulf of California, the LCRB contains both lentic and lotic razorback sucker habitat (Figure 17). Spawning grounds are present and commonly used in both Lake Mead and Lake Mohave, in the Colorado River between Davis and Parker dams (Lake Havasu) and in the Colorado River below Parker Dam (Kesner *et al.* 2014; Mohn *et al.* 2017; Kesner *et al.* 2017; L. J. McCall *et al.* 2017). Natural and modified backwaters and floodplain habitat types are available for razorback sucker throughout the LCRB including oxbows, abandoned river channels, secondary channels, and isolated coves in reservoirs (Saiki *et al.* 1980; Valdez *et al.* 2012). Additionally, disconnected backwaters are created and managed by the LCR MSCP as refugia for stocked razorback sucker. Growth rates and body condition of adults in LCRB reservoirs are high, indicating the abiotic features formed by reservoirs can be diverse, and alone may be beneficial to adults of the species. However, with the exception of Lake Mead, recruitment is non-existent or limited by the persistent presence of nonnative fish.

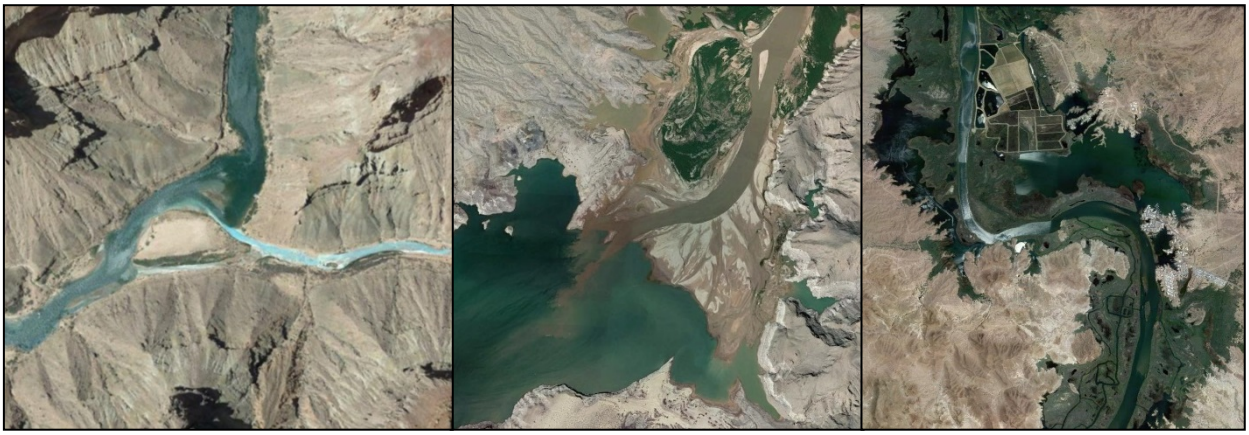


Figure 17. Complex lotic and lentic habitat within the LCRB. The Little Colorado River confluence in the Grand Canyon (left), the Colorado River confluence to Lake Mead (center), and Imperial Ponds and other off-channel features below Parker Dam (right) (from Google Earth).

The Lake Mead population has access to Colorado River in Western Grand Canyon, providing additional diverse habitat. When Lake Powell filled in the mid-1960's, Lake Mead elevations were dramatically decreased, allowing for the establishment of near-shore vegetation. From 2012-2015, water level drawdown associated with drought has allowed terrestrial vegetation to colonize in a downslope direction, which when coupled with annual elevation increases during spring may be providing cover in coves and other habitats that allow for the recruitment occurring there (Mohn *et al.* 2017). The complex vegetation coupled with high levels of turbidity near the inflows makes recruitment successful, especially in the Virgin River/Muddy River inflow and Las Vegas Bay (Mohn *et al.* 2017). Lake Mead has a sizeable nonnative fish presence, currently dominated by gizzard shad, common carp, striped bass, largemouth bass, smallmouth bass, black crappie and bluegill (Mohn *et al.* 2017).

After the creation of Lake Mohave in the 1950's, one of the largest remaining populations of razorback sucker persisted in the reservoir for many years but had declined by the early 1990's (Marsh *et al.* 2003; W. L. Minckley *et al.* 2003). Multiple spawning grounds are visited annually, where razorback sucker clear silt from gravel beds. Unlike Lake Mead, there is little inundated shoreline vegetation, low habitat complexity and low levels of turbidity, potentially limiting cover for juveniles attempting to escape predation. Striped bass are plentiful in the reservoir and are a documented source of juvenile and adult mortality of razorback sucker (Karam and Marsh 2010).

The Lake Havasu population occupies the reach between Davis and Parker dams, including 54 miles of the Colorado River and the entirety of Lake Havasu. Annual spawning congregations are found from Laughlin, Nevada downstream to Needles, California (Kesner *et al.* 2017). Fish have access to a variety of habitats, including fast-flowing waters in the riverine section below Davis Dam, low lying rocky canyon-like shorelines with backwater habitat as well as gently sloping shorelines in the reservoir (Kesner *et al.* 2017). Conditions of cover and turbidity are similar to Lake Mohave and most likely do not provide sufficient cover for larval fish to escape predation by nonnative fish. However, the Bill Williams River inflow to Lake Havasu has similar physicochemical characteristics to those of Lake Mead inflows including vegetative cover and occasional turbidity (Humphrey et al 2014, 2016; Karam et al. 2013) but little utilization by stocked bonytail or razorback sucker.

Below Parker Dam miles of lotic and lentic habitat extend to Yuma, Arizona. Both channelized and natural reaches contain a variety of in-channel habitats (sand bars that create side channels and eddies) and natural and reconstructed backwaters that are connected to the lower Colorado River. Conservation actions have been implemented to create isolated backwaters that are representative of historical conditions during low-flow periods (U.S. Department of Interior 2005). Conditions of cover and turbidity are similar to Lake Mohave and most likely do not provide sufficient cover for larval fish to escape predation by nonnative fish.

5.2.2 Suitable water temperature and quality

The construction of large mainstem dams has altered water temperatures throughout the LCRB. One example is the Colorado River through the Grand Canyon, which historically experienced diel and seasonal temperature variations from freezing in the winter to near 30 °C in late summer. Before the construction of Glen Canyon Dam, the warmest water temperatures were in July and August (Valdez and Carothers 1998). Because of the hypolimnetic release of water through the dam, water temperatures at Lee's Ferry range from approximately 8 to 14 °C, with the warmest temperatures occurring in October and November (U.S. Geological Survey 2016a). This water warms to over 20 °C as it flows downstream into Lake Mead. Lake Mead water temperatures ranged from 10.4 to 31.2 °C in 2010 in the Temple Basin just downstream of the Colorado River Inflow (CRI) (U.S. Geological Survey 2016b). From Lake Mead, water is released into Lake Mohave where water temperatures ranged from 11.0 to 30.6 °C in 2014 (U.S. Geological Survey 2016b). Similarly, water temperatures downstream of Lake Mohave in Lake Havasu ranged from 12.9 to 28.6 °C in 2014 (Central Arizona Project 2015). Warm releases from Glen Canyon Dam in association with low reservoir levels have been investigated,

providing insight to the possible effects of warming on native and nonnative fishes in the Grand Canyon either from low reservoir levels or use of a temperature control device.

Despite cooler water temperatures, relative lack of nutrients, and much reduced sediment transport, razorback sucker are spawning in the Grand Canyon (Albrecht *et al.* 2014; Kegerries *et al.* 2015), recruiting in Lake Mead (Albrecht *et al.* 2010; Mohn *et al.* 2015), and reproducing in Lake Mohave (Delrose 2012). Razorback sucker appear to be opportunistic and successful at spawning in a variety of water temperatures, but water temperature does play an important role in hatching, growth, and survival of larvae (Marsh 1985; Bozek *et al.* 1990; Bestgen 2008).

Water quality in the LCRB is thought to be sufficient to support all life stages of razorback sucker, but elevated concentrations of selenium are found near Imperial Dam (Engberg 1999). Thus, the same suite of concerns and controversy around the effects of selenium observed in the UCRB apply here as well.

5.2.3 Variable flow regimes

Creating spawning and rearing habitat through higher spring flows and connecting backwater and floodplain habitat types is an important aspect of supporting razorback sucker life history, but it may not be possible given the high degree of river regulation, nonnative fishes and habitat changes in the LCRB. Variable flow is thought to be important in the lotic components of razorback sucker habitat, but not essential in reservoir habitat. Some annual variation in reservoir level is thought to support various life stages, but dramatic increases or decreases in reservoir stage can have deleterious effects, especially during spawning season when eggs may be dried by falling water levels (L. J. McCall *et al.* 2017).

Discharge has been altered through the construction of dams and water development within the LCRB. Flows in the Grand Canyon are largely dependent on dam releases rather than natural runoff events, although monsoonal flooding through major tributaries (e.g. Little Colorado River, Paria River) can produce significant increases in main channel flow. Dam releases and operations have changed at Glen Canyon Dam and throughout the Grand Canyon since the first decades following dam completion, resulting from research conducted by the Glen Canyon Adaptive Management Program. The releases prior to 1991 included large diel fluctuations (nearly 15,000 cfs/day). Flows currently fluctuate with diel hydropeaking operations at Glen Canyon on the order of approximately 5,000 to 8,000 cfs/day in most years, with the largest fluctuations tending to occur in summer months.

Discharge below Davis (Lake Mohave) (Figure 18), Parker (Lake Havasu), and Imperial (Imperial Reservoir) dams is also dependent on water released through each dam. Daily fluctuations based on power generation can also affect shallow-water habitats below Hoover, Davis, and Parker dams. The river that once experienced seasonal variation in flow with higher summer flows followed by winter base flows now has more static hydrographs (Figure 18) to maintain reservoir water levels and distribute water throughout the Southwest. Similarly, the Verde, Gila, and Salt rivers have been impacted through water development and experience regulated flow regimes in their lower reaches. Stability of flows may advantage some nonnative species. Given that the state of the mainstem and high numbers of nonnative fishes downstream

of Lake Mead, much effort has been exerted to create backwaters that are disconnected from the mainstem to minimize impacts from nonnative fishes and promote razorback sucker survival (Minckley *et al.* 2003; LCR MSCP 2004).

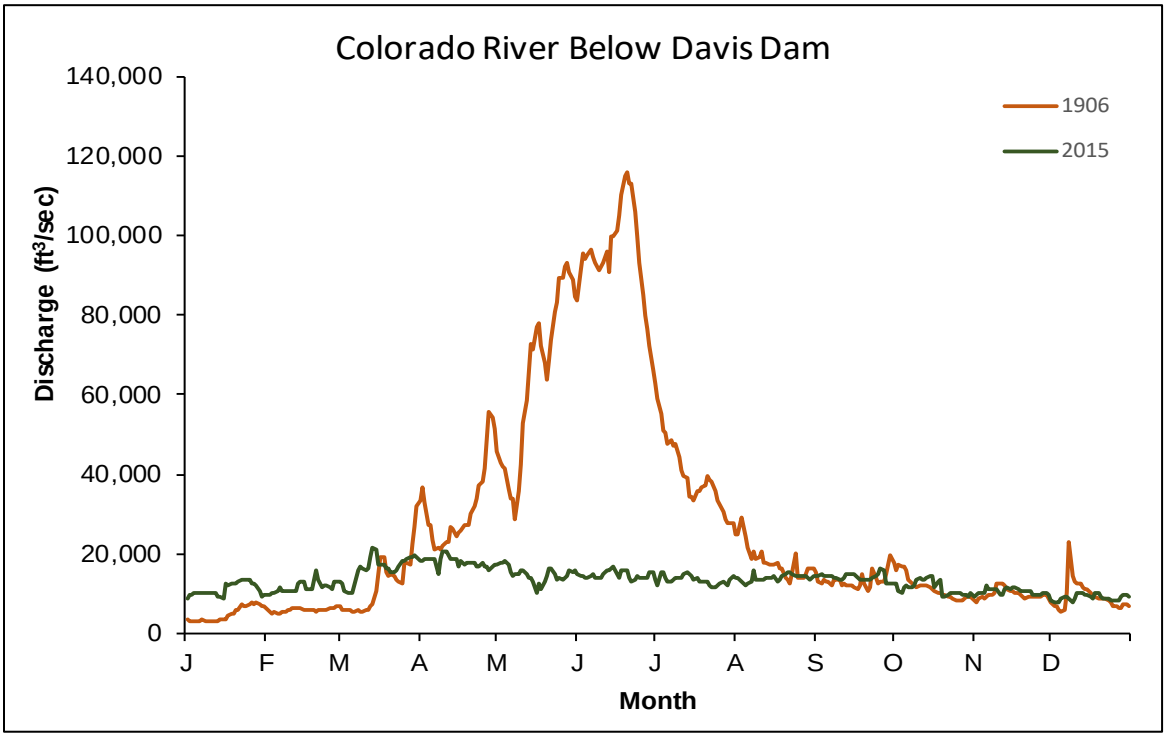


Figure 18. Mean daily discharge from the Colorado River below Davis Dam in 1906 (pre-dam) and 2015 (post-dam). Data acquired from U.S. Geological Survey (USGS) gauging station 09423000.

5.2.4 Food Supply

Research related to the abundance and availability of food for razorback sucker in the LCRB is relatively limited, but nonetheless food supply is thought to be adequate to support growth and survival in all lower basin reservoirs.

Most of research related to food supply is from the Grand Canyon and more specifically, to humpback chub. The food base in the Grand Canyon was identified as a potential limiting factor for native species (Valdez and Ryel 1995; Valdez and Carothers 1998). Food web dynamics in the Grand Canyon show longitudinal patterns correlating with large tributaries. Nonnative New Zealand mudsnails *Potamopyrgus antipodarum* and rainbow trout dominate areas below Glen Canyon dam and above the inflow of the Paria River where invertebrate production is lower, but fish production is dominated by native taxa and more similar to a stable food web below tributaries (Cross *et al.* 2013). Because of clear water releases from Glen Canyon Dam and greater light penetration, the Colorado River in Glen Canyon above the Paria River is dominated by green algae, diatoms, chironomids and amphipods. In the reaches below the Little Colorado River, the dominant taxa are blue-green algae, diatoms, chironomids, and simuliids (Hardwick *et al.* 1992; Valdez and Carothers 1998). One study on Lake Mohave and nearby backwaters showed abundance of food items and similarities in food availability for larval razorback sucker in both habitats. Differences in potential razorback sucker food items were also found from Lake

Mohave downstream to the Imperial Dam. Potential food items were greatly decreased below Davis Dam with increases in detritus, plankton, and macroinvertebrates from Lake Havasu downstream (Minckley 1979).

5.2.5 Range and Connectivity

In much of the LCRB, razorback sucker are restricted to specific reaches of river, specific impoundments, and in some cases to specific backwater and floodplain type habitats, mainly due to constraints imposed by predation and habitat modifications (dams) common within the LCRB (Minckley *et al.* 2003). If there is little or no movement of individuals among populations, then the number of individuals in each population is dependent on its own demographic attributes and population dynamics, or is dependent on management of these populations through augmentation or mixing (e.g., Minckley *et al.* 2003, Kesner *et al.* 2016).

Because of predation vulnerability and large dams throughout the LCRB, connectivity between populations is limited to manual translocation of fish from one population to another. Telemetry has documented movement between reservoir populations and the lotic habit upstream in both Lake Mead and in the Colorado River between Davis and Parker Dams (Lake Havasu) and from small population centers to others within each geographically defined population (Bunch *et al.* 2012; Albrecht *et al.* 2014; Kegerries *et al.* 2015).

5.2.6 Summary of Lower Basin Resource Conditions

Table 7. Summary of lower basin physical resources current condition for razorback sucker (high condition is represented by green, medium condition by yellow, low condition by orange and extirpated condition by red).

	Physical Needs					
	Complex Lotic/Lentic Habitat					
	Habitat	**Nonnative presence in habitat**	**Water Quality/Temperature**	**Variable Flow (lotic only)**	**Adequate Food**	**Range & Connectivity**
Lake Mead (including Grand Canyon)	MEAD • Spawning areas are present sufficient for reproduction to occur frequently in the lake, but shift with lake levels; razorback sucker maintain spawning areas by clearing silt • Inflow areas have high turbidity which provides the majority of the cover •Inundated vegetation exists dependent on lake level, juveniles use areas heavily covered by tamarisk, which may allow them to escape predation • Adequate adult habitat exists and adults shift seasonally between shallow and deeper waters	• Nonnative predators are common in the lake and managed as sportfish	• Water quality is sufficient to support all life stages • Water temperatures appear conducive to growth and reproduction (seasonal fluctuations; 12-29 C)	• Not applicable in Lake Mead	• Abundant food is present for all life stages in Lake Mead, resulting in high body condition factors in this population	• Movement occurs throughout the reservoir. Upstream and downstream movement occur between the Grand Canyon and Lake Mead proper. Movement is blocked from all other populations
	GRAND CANYON • Spawning areas are present sufficient for reproduction to occur frequently in the Grand Canyon including tributary mouths • No off channel habitat is available, connected backwaters may provide more productive environments for larvae but are not consistently available • Adequate adult habitat exists; including deep pools and large areas of open water	• Nonnative predation/competition in Western Grand Canyon (below Lees Ferry) is rare as the community is 95% native	• Artificially low temperatures in Grand Canyon delay spawning in comparison to the Lake Mead population	• Majority of flows in Grand Canyon are stable compared to other LCRB locations, with periodic high flow events managed by Glen Canyon Dam which generally occur in the fall, outside of spawning periods	• Western Grand Canyon is depauperate in food base, in both quantity and diversity	• A significant barrier/rapid (Pearce Ferry Rapid) has formed at Pearce Ferry that could limit connectivity for fish that want to move further upstream past the rapid during low flow.
Lake Mohave (including all river below Hoover dam) LCR MSCP Reach 2	• Spawning locations are consistent from year to year; razorback sucker annually clear silt from long-term cobble-bottomed spawning locations • Limited inundated shoreline vegetation, low habitat complexity and low turbidity levels provide limited cover for juveniles• Adequate adult habitat exists; including deep pools and large areas of open water	• Nonnative predators are dominant in the lake and managed as sportfish	• Water quality is sufficient to support all life stages	• Not applicable in Lake Mohave	• Adequate food is present for all life stages	• Movement occurs throughout the reservoir, but is blocked from all other populations.
Lake Havasu (below Davis dam to Parker dam) LCR MSCP Reach 3	• Cobble is present and commonly used for spawning near Needles - Laughlin • Complex backwater/slack water habitat available with varying levels of turbidity • Connected backwaters present throughout the upper riverine portion and Topock Gorge • Adequate adult habitat exists; including deep pools and large areas of open water • Known populations found within the riverine section and associated backwaters	• Nonnative predators are dominant in the lake and managed as sportfish • Large populations of striped bass and flathead catfish prevent recruitment	• Water quality is sufficient to support all life stages • Water temperatures in the lake appear conducive to growth and reproduction (seasonal fluctuations; 12-29 C)	• Flows are stable below Davis Dam, reducing peak flows and modifying base flows	• Adequate food is present for all life stages	• Movement occurs throughout the reach, but is blocked from all other populations.
Colorado Mainstem Below Parker Dam LCR MSCP Reaches 4 & 5	• Cobble bars are present in backwaters and river sections; use by razorback sucker has not been documented • Complex backwaters are limited above Palo Verde Dam and become numerous below • Adequate adult habitat exists; including deep pools and large areas of open water	• Nonnative predators are dominant in the river and prevent recruitment	• Water quality is sufficient to support all life stages, but typically have high salinities and high temperatures	• Flows are stable out of Parker dam and vary with seasonal demand, base flows have been modified • Flows have been greatly reduced in these reaches	• Adequate food is present for all life stages	• Movement is blocked from all other populations by Parker Dam, Headgate Dam and Palo Verde Dam

5.3 Status of Populations

5.3.1 Upper Colorado River Basin

The UCRB basin can be subdivided into four geographic areas representing populations including the Green River subbasin, the upper Colorado River subbasin (defined as the area above Lake Powell excluding the Green River subbasin), the San Juan River subbasin, and Lake Powell.

In the UCRB, razorback sucker are primarily found in the Colorado River, Green River, and San Juan River, with the largest population occurring in the Green River. In recent years, captures and detections of razorback sucker were the results of stocking to maintain populations. Since 2000, over 560,000 razorback sucker have been stocked into the UCRB and 53,854 unique individuals have been captured or detected via PIT-tag scanner (Table 8) (STReaMS 2016). Captures refer to interactions with field staff, either at fish passage structures or active sampling methods. Detections refer the number of fish that interacted with stationary or temporary antennas which record PIT tags that pass within their range. Tributaries that historically contained razorback sucker (Yampa, White, Duchesne, and Animas rivers) harbor few individuals that are limited to lower reaches near the confluences with the Green, Colorado, or San Juan rivers. In the Green, Colorado, and San Juan rivers, razorback sucker captures and detections are widespread.

Table 8. Number of razorback sucker captured, detected, and stocked in the UCRB since 2000 (STReaMS 2016 published and unpublished data; note that at time of writing that STReaMS was still being populated and sampling effort varies among rivers).

Stream or Waterbody	Subbasin	Captured	Individuals Detected	Stocking
Total		**37,936**	**15,918**	**560,186**
Colorado River	Colorado	7,570	1,076	144,780
Dolores River	Colorado		30	
Gunnison River	Colorado	486	109	46,387
Roubideau Creek	Colorado		4	
Above Brennan	Green	11		
Duchesne River	Green	24		
Green River	Green	11,819	6,145	201,603
Green River Canal	Green		1,283	
Green River Wetlands	Green	1,552		8,208
Johnson Bottom	Green	46	6	
Price River	Green		74	
San Rafael River	Green	3	1,179	
Stewart Lake	Green	2,175		
Stirrup	Green	1		
White River	Green	185	66	
Yampa River	Green	8	21	30
Lake Powell	Lake Powell	661	131	73
Animas River	San Juan	52		23,192
Chaco River	San Juan	1		
Chinle Creek	San Juan	1		
Hogback Canal	San Juan		1,275	

Stream or Waterbody	Subbasin	Captured	Individuals Detected	Stocking
Total		**37,936**	**15,918**	**560,186**
McElmo Creek	San Juan	4	512	
Montezuma Creek	San Juan			411
San Juan River	San Juan	13,337	4,007	135,502

5.3.1.1 Green River Subbasin

The Green River is typically divided into three reaches for sampling: the middle Green from the mouth of Whirlpool Canyon to near the White River confluence (RKM 539.4-396.0), Desolation-Gray from the White River confluence to Green River, Utah (RKM 334.0-246.0) and the lower Green from Green River, Utah to the confluence with the Colorado River (RKM 193.2-0). In 1989, the middle Green River razorback sucker population was estimated at 948 adults (95% CI = 758–1,138) (Lanigan and Tyus 1989). Eight years later, the population was estimated at 524 adults (95% CI = 351–696), and was characterized as being stable or declining slowly with some evidence of recruitment (Modde *et al.* 1996). In the lower reach of the Green River, available data were insufficient to estimate numbers of razorback sucker adults (Modde *et al.* 1996). Bestgen *et al.* (2002) estimated that the population of wild adult razorback sucker in the middle Green River was about 100 based on sampling in 1998-1999. A few individual razorback sucker were captured in the vicinity of the San Rafael River confluence small numbers of larvae and juveniles indicated probable spawning.(Gutermuth *et al.* 1994; Chart *et al.* 1999; Muth *et al.* 2000; Bestgen *et al.* 2002). The extirpation of wild fish prompted stocking efforts managed by the UCREFRP.

The number of razorback sucker has been increasing in the Green River subbasin since the early 2000s through stocking. Population estimates using capture data from 2011– 2013 are available for the lower Green River, Desolation–Gray canyons, and the middle Green River. Model-averaged estimates for the subbasin peaked over 30,000 individuals in 2012 and 2013 (Figure 19; 36,355, 95% CI: 17941-74854) (Zelasko *et al.* 2018). The authors encourage caution as these estimates are based on low capture probabilities and insufficient recapture events during the study period. However, the results offer an indication of a large resident population.

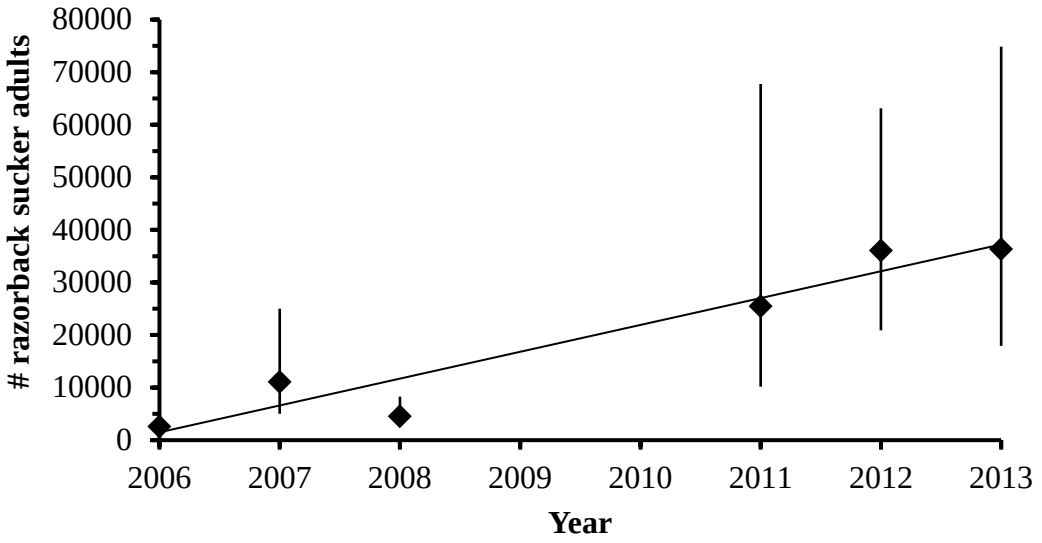


Figure 19. Model-averaged abundance estimates and 95% confidence intervals (vertical bars) for razorback sucker captured in the Green River, Utah, 2006-2013, from Zelasko *et al.* 2018.

Evidence of successful reproduction (larval drift) has been documented every year since collection began (in about 1993) in the middle Green River near Jensen, mostly below Razorback Bar. Bestgen *et al.* (2007) also documented a probable razorback sucker larva originating in Lodore Canyon, which is upstream of Razorback Bar. Larval concentrations and timing are documented annually, varying with flow and temperature (Bestgen and Jones 2017). Field crews reported the capture of unmarked juvenile individuals (114 across all in-river projects [STReaMS 2016]) indicating a limited degree of wild recruitment to this life stage in the basin. Larval fish in the lower Green River have been regularly present since 2009 when monitoring began (Badame 2009), though typically earlier in the season than in the middle Green River. Ripe razorback sucker were captured in a cobble side channel at river mile 103.7 in 2008, three age-1 juveniles (119-120 mm TL) were captured between river miles 18 and 44 in 2008 in the lower Green River (Badame 2009). Recruitment relies on relatively few and small-scale in-channel features such as flooded washes or backwaters for rearing habitat; floodplain wetland habitats are rare in this section.

Razorback sucker spawning and larval presence has been documented in tributaries to the Green River. Very low levels of spawning were documented in the Yampa River, suggesting a small population of razorback sucker exists upstream of Echo Park. Captures of razorback sucker larvae in the White River confirm spawning and the increasing range of fish stocked in the Green River (Webber *et al.* 2013). Remote PIT-tag scanning data from the San Rafael River from 2008 to 2010 showed 20 razorback sucker utilizing the river during spring runoff (Bottcher *et al.* 2013). Similar patterns have been documented in the Price River (Budy *et al.* 2017). Use of the Duchesne River by razorback sucker was suggested by migration of a radio-tagged razorback sucker into the tributary (Tyus *et al.* 1981).

Implementation of the LTSP (LaGory *et al.* 2012) has shown success through larval entrainment and survival to juvenile size classes in flooded wetlands in recent years (Jones *et al.* 2015; Schelly and Breen 2015). From 2013-2018, Stewart Lake floodplain (near Jensen, Utah) was managed to encourage razorback sucker recruitment in conjunction with LTSP flows. The wetland is kept dry and therefore free of nonnative predators until managed spring flows triggered by razorback sucker larval presence flood the wetlands. Inflows were screened to prevent nonnative predator introduction. The wetland is maintained with supplemental water through the summer and then drained into the Green River in the fall. During each annual draining event, young-of-year razorback sucker were captured in a fish trap and released back into the river, with the largest cohort occurring in 2016 (Table 9) (Schelly *et al.* 2016). The growth of razorback sucker in Stewart Lake may improve these individuals' chances of overwinter survival (Schelly *et al.* 2014). Conditions in Stewart Lake changed annually based on habitat conditions, available flow, number of larvae available to be swept into the wetland during the spring peak flow and number of days the wetland was operational (Skorupski *et al.* 2013; Schelly *et al.* 2014; Schelly and Breen 2015; Schelly *et al.* 2016; Staffeldt *et al.* 2017b). In spring 2018, dense cattail stands were burned in an attempt to restore previous habitat available to growing larvae.

Table 9. Wild-produced razorback sucker sampled and released as young-of-year from Stewart Lake.

Year	Count
2013	592
2014	749
2015	97
2016	2110
2017	2

LTSP represents a major step forward in the recovery of the species. The method of entrainment has been repeated at Johnson Bottom, Sheppard Bottom and Wyasket Lake resulting in varying degrees of success, none of which match the success of Stewart Lake. Adult recruitment in the basin is rare, if present. Untagged adults have been found (223 from 2010-2017), but at levels that could likely be attributed to tag loss and not recruitment. The lack of recruitment is thought to be a result of predation by large-bodied fish (northern pike, smallmouth bass, and walleye), competition and predation in wetlands among small-bodied fish, the relatively new implementation of LTSP and other flow recommendations and other factors.

Stocking of razorback sucker continues at robust levels in the upper basin. Since 2000, more than 209,000 fish were stocked into the Green River subbasin (STReaMS 2016). Razorback sucker averaging 252.5 mm TL stocked into the UCRB from 1995–2005 survived their first year in the river at a rate of 0.05 (when averaged across stocking season) while 300-mm-TL fish were estimated to survive at a rate of 0.15 (Zelasko *et al.* 2011). Similarly-sized razorback sucker (average length 300 mm) stocked during the 2004–2007 study period had an estimated mean initial (first year) survival rate of 0.09 and subsequent survival ranging from 0.79-0.94 depending on rearing environment (Zelasko *et al.* 2011). The Revised Integrated Stocking Plan (Integrated Stocking Plan Revision Committee 2015) now recommends stocking 6,000 fish into the Green River annually with average sizes exceeding 350 mm TL.

Genetic diversity is not a concern in this population as genetics are maintained through broodstock management. However, all upper basin populations have lower genetic diversity than populations in the lower basin (Dowling *et al.* 2012). Hybridization risk is low in the Green River, however, hybridization with nonnative white sucker among flannelmouth and bluehead sucker may be increasing in some areas of the subbasin, including the Lodore/Whirlpool reach (Bestgen *et al.* 2007). Experts believe that white sucker hybrids may increase the likelihood of hybridization with all sucker species (Bestgen *et al.* 2007). Abundance of hybrid combinations have increased over time (Bestgen *et al.* 2007). Particularly common were hybrids that had white sucker as one parental type. Occurrence of white suckers and hybrids declined in a downstream direction in Lodore Canyon.

Although the population in the Green River is robust and incidents of human-aided juvenile recruitment are increasing, concerns regarding the stability of the population remain. The Green River population is stable only through annual stocking efforts. The population is not self-sustaining and likely to decrease quickly should stocking efforts cease.

5.3.1.2 Colorado River Subbasin

The Colorado River subbasin encompasses the Colorado, Dolores and Gunnison rivers and their tributaries and ends at the inflow to Lake Powell. The number of wild razorback sucker captured in the Colorado River subbasin has been low since the 1970's (McAda 2003). The greatest number of razorback sucker captured in this subbasin was in 1975 with 206 individuals captured. Between 1990 and 2003, only 11 wild razorback sucker were captured, all of which were brought into captivity and incorporated into the propagation program (McAda 2003).

The number of razorback sucker encountered in the basin has been increasing as stocked fish survive and accumulate. Monitoring in the Colorado River occurs in conjunction with Colorado pikeminnow sampling, which are conducted for three consecutive years followed by two years without sampling, after which surveys resume. In 2008-2010, preliminary population estimates ranged from 2,449-4,895 adult individuals. Sampling in 2013-2015 produced preliminary population estimates ranging from 5035-8078 for the same reach (Colorado River between Palisade and the confluence with the Green River in Utah; Figure 20, Elverud *In prep*).

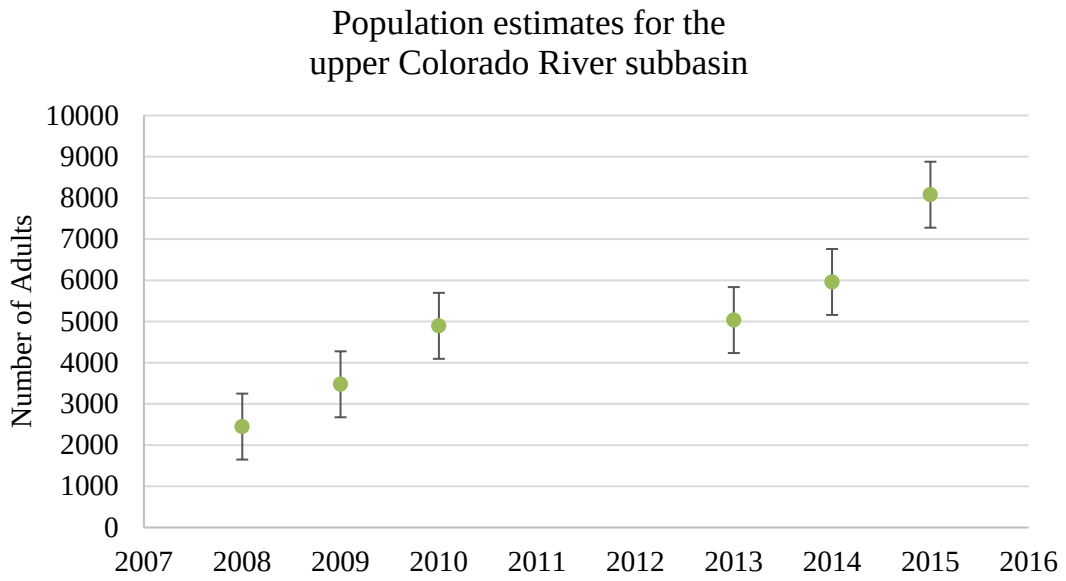


Figure 20. Razorback sucker population estimates (and 95% CI) by year for the Colorado River between Palisade and the confluence with the Green River (preliminary estimates from data gathered during Colorado pikeminnow sampling) as presented in Elverud *in prep*.

As evidenced by ripe fish and larval collections, razorback sucker spawning is currently occurring throughout the Colorado River subbasin. Ripe fish and larvae have been collected in the '15 and 18-mile reaches' of the Colorado River through the Grand Valley and in 30 miles of the Gunnison River directly above the confluence with the Colorado River (Elverud *in prep*; D. B. Osmundson and Seal 2009). Access to the Gunnison River has been restored by the UCREFRP by the construction of a fish ladder, trap and daily sorting to prevent nonnative fishes from accessing the river. Razorback sucker also appear to be regularly present during spring runoff in the Dolores River, suggesting spawning activity (David Speas, U.S. Bureau of Reclamation, personal communication, March 2018).

Recruitment to the juvenile stage in the Colorado basin is rare, but has been confirmed at low levels. In 2012, three young-of-year fish were captured in the Colorado River, and another fish confirmed to be wild was found in an off-channel pond. In 2013, 39 razorback sucker juveniles were caught during monitoring targeting Colorado pikeminnow (Francis, Ryden *et al.* 2013b). The juvenile fish were collected across almost 70 river miles, in the months of May and June under a variety of flow conditions (Francis *et al.* 2013b). A single juvenile (115 mm TL) was collected just below Westwater Canyon in 2018 (Travis Francis, U.S. Fish and Wildlife Service, personal communication, May 2018). Recruitment from juveniles to adults is rare. If occurring in the basin, it is most likely due to persistent predation from nonnative fishes and lack of rearing habitat. Several untagged adults have been found, but could be attributed to tag loss.

Since 2000, 191,000 razorback sucker have been stocked into the Colorado River subbasin. Prior to 2013, the Colorado River received approximately 10,000 stocked fish per year and the Green River received almost 20,000 fish. In 2015, the Revised Integrated Stocking Plan (Integrated Stocking Plan Revision Committee 2015) changed guidance to reduce stocking numbers, but increase size of the fish stocked. The Ouray National Fish Hatchery in Vernal, Utah and the

Ouray National Fish Hatchery in Grand Junction, Colorado currently each produce 6,000 razorback sucker with average lengths of 350 mm or more. In most years, stocking events are split between the Green and Colorado subbasins.

Razorback sucker stocked from 1995–2005 have demonstrated better survival when they are stocked in the fall, winter and spring and at larger sizes (greater than 300 mm) (Zelasko *et al.* 2009). First year survival across all size classes ranged between 0.07 and 0.08 when not stocked during the summer months. Overall survival rates through subsequent intervals was estimated at 0.75 (95% CI: 0.688-0.801) (Zelasko *et al.* 2009). The collection of larvae indicated that these stocked fish were behaving as wild fish by migrating and spawning in the Gunnison and Colorado rivers (D. B. Osmundson and Seal 2009).

Genetic diversity is not a concern in this population as genetics are maintained through broodstock management. Since 2000, 88 razorback sucker hybrids have been captured in the Colorado basin, all of which have been identified as razorback x flannelmouth, razorback x bluehead or razorback x flannelmouth x bluehead crosses (STReaMS 2016). Hybrids represent less than 0.1% of razorback sucker captured in the basin, which is not considered a threat to genetic diversity. Most captures have occurred since 2012, but it is unclear as to whether or not the pattern stems from increasing hybridization or better field identification by biologists.

In summary, this razorback sucker population has been increasing over time, but increases are driven by improved stocking success. Recruitment of fish to the adult life stage is rare and suppressed by the continued presence of nonnative fishes and lack of rearing habitat in most rivers. The population is not self-sustaining and is reliant on continued stocking.

5.3.1.3 San Juan River Subbasin

In the San Juan River, the long-term monitoring catch-per-unit-effort for adult razorback sucker has been steadily increasing since 2003 due to stocking; since 2010 catch rates have been significantly higher than catch rates during 2003–2009 (Schleicher 2016). Population estimates for razorback sucker have been developed for the San Juan River from Shiprock, New Mexico to Sand Island, Utah (approximately 70 river miles) using capture data from various sampling efforts (Figure 21). The estimates indicate the razorback sucker population in the San Juan River is relatively stable around 3000 adults (San Juan River Basin Recovery Implementation Program 2017). The vast majority of the fish used in the estimate were stocked razorback sucker, but untagged fish were captured during data collection were used in the estimates.

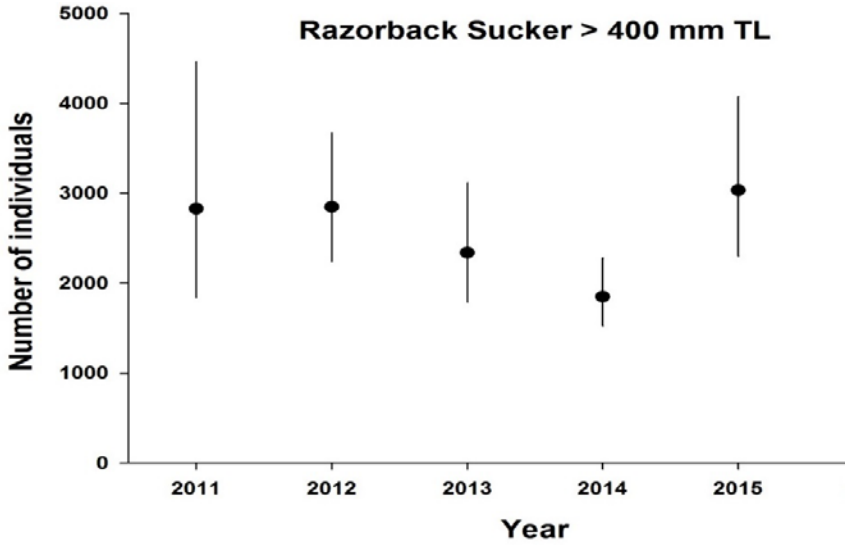


Figure 21. Population estimates for adult (> 400 mm TL) Razorback Suckers) razorback sucker in the San Juan River above the waterfall from 2011-2015 (San Juan River Basin Recovery Implementation Program 2017). Error bars represent 95% confidence intervals.

Razorback sucker spawning and subsequent larval presence has been documented in the San Juan River annually since 1998 (Farrington *et al.* 2018), however the percentage of adults participating in spawning in any given year is low (~2% of the adult population) (Diver and Wilson 2018). Larval collections have been relatively stable over the last decade and larvae are distributed throughout the reaches sampled on the San Juan. Opercular deformities have been seen in larvae at rates of 17.6% in 2016 and 13.1% in 2017, which are higher than in other native species (Farrington *et al.* 2018). The causes of the deformities are unknown but could be attributed to temperature, nutrition or contaminants (Barkstedt *et al.* 2015).

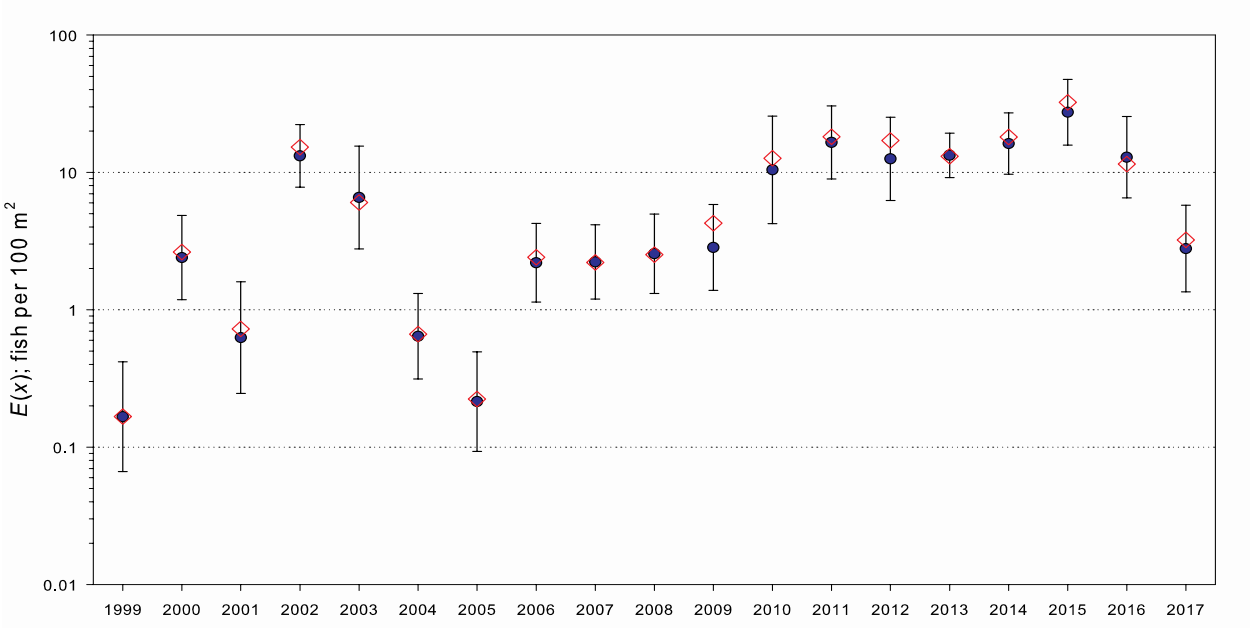


Figure 22. Razorback sucker estimated larval densities (noted by E(x)) in the San Juan River over time (Farrington *et al.* 2018). Solid circles indicate estimates and error bars represent 95% confidence intervals Red diamonds indicate simple estimates of mean densities using the method of moments.

Larval collection rates are comparable to those of other sucker species native to the San Juan basin early in the season (April-May), a trend that does not continue into summer months or more advanced life stages (Figure 23). Reasons for this decline are currently being explored by the SJRIP.

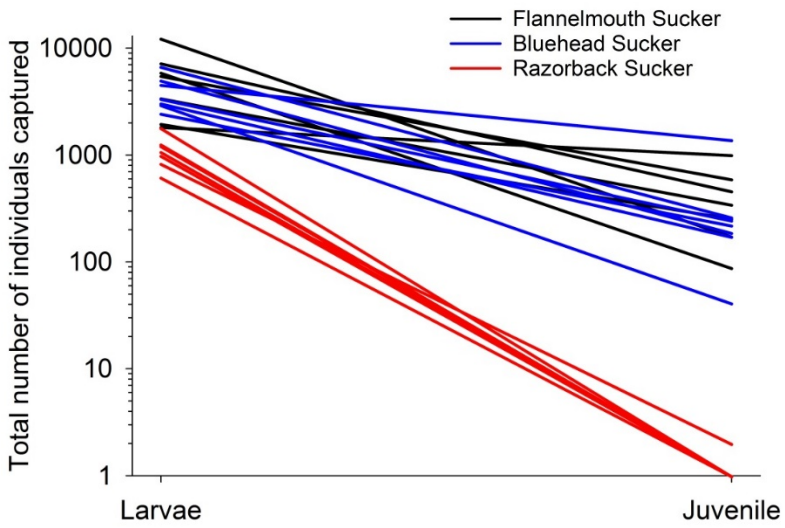


Figure 23. Number of larvae and juvenile sucker species captured in the San Juan River (San Juan River Basin Recovery Implementation Program 2017).

Recruitment to both the juvenile and adult life stages is rare in the San Juan subbasin. Current theories regarding the lack of recruitment include high emigration, the limited number of spawning adults, and a lack of available rearing habitat, all of which are being explored by the SJRIP.

The population remaining in the San Juan subbasin is maintained by stocking efforts and is not self-sustaining. Planning documents mandate the annual stocking of 11,400 razorback sucker greater than 300 mm TL. More than159,000 razorback sucker have been stocked in the San Juan between 2000 and 2017 (STReaMS 2016).

Genetic integrity is currently managed by the propagation efforts of SJRIP and therefore inbreeding should not be a concern as long as the program is maintained. Should survival of young increase without a corresponding increase in the number of adults participating in spawning, inbreeding may become a concern. Hybridization with other sucker species can occur, but is rare in the basin.

5.3.1.4 Lake Powell

Many questions remain regarding the role of Lake Powell in the Upper Basin populations; it is likely that razorback sucker in the Colorado River and San Juan River inflow areas are extensions of populations found in the Green, Colorado and San Juan rivers rather than an independent population. It is important to note that evaluating the riverine populations with the inclusion of Lake Powell information may provide a more complete picture of population

dynamics, but data are not currently available to make conclusions. Lake Powell is not regularly monitored like the other three upper basin populations and much uncertainty remains about the status of this population. Although it is suspected to be a promising location for razorback sucker, more research and monitoring are needed.

Traditional population estimates are not available for the entire population of Lake Powell, but population estimates have been developed for portions of the lake (Table 10). Catch per unit effort data is also available for both arms of Lake Powell (San Juan arm = 0.017 fish/net-hour [SE=0.003], Colorado arm = 0.067 fish/net-hour [SE=0.006]). These levels are similar to Lake Mead (range of 0.07-0.092 fish/net-hour) (Albrecht *et al.* 2017).

Table 10. Recent adult razorback sucker population estimates for various areas in Lake Powell.

Location	Years Sampled	Point Estimate	95% Confidence Interval	Source
Lake Powell (Colorado River arm)	2010-2016	2,184	1,784–2,713	Albrecht *et al.* (In prep)
Lake Powell (San Juan River arm)	2011-2012	527	248–1,311	Francis *et al.* 2015
Lake Powell (San Juan River arm)	2017	572	549–595	Cathcart *et al.* (In press)

Available data confirms exchange of individuals between Lake Powell and all three other populations, leading to the conclusion that the inflow areas could be extensions of the other basin populations. Lake Powell is assessed here as a "population" for two reasons: population estimates exist for areas of the lake itself and the degree of connection to any other population is difficult to define. The two major inflow areas (the San Juan River and Colorado River) display characteristics that likely provide suitable habitat for razorback sucker recruitment. It is likely that these large, turbid, warmer lentic environments are functioning similarly to historic backwaters, floodplains, oxbows, and isolated off-channel ponds where reproduction and recruitment historically occurred (R. S. Wydoski and Wick 1998; Mueller *et al.* 2001; Mueller 2006). Recent studies documented inflows of the Colorado River and some of its reservoir tributaries as harboring spawning, and perhaps razorback sucker populations recruiting to the adult life stage (Francis, Ryden *et al.* 2013a; Francis *et al.* 2015; Kegerries *et al.* 2015).

Reproduction appears to be occurring annually and larval razorback sucker have been captured in inflow areas (Francis *et al.* 2015; Albrecht *et al.* 2017). Reproduction also is occurring upstream of inflows to Lake Powell, which may supply additional larvae to the reservoirs via larval drift, but recruitment has yet to be confirmed.

Multiple studies indicate the presence of untagged fish in the San Juan arm of Lake Powell. Sampling events in 2011–2012 noted 36% of individuals (53 adults) captured were untagged (Francis *et al.* 2015). In a separate study conducted from 2010-2016, 44% of individuals (72 adults) captured were untagged and fin ray aging data indicated ages of 7-17 years, or potential recruitment years between 1992 and 2005 (Albrecht *et al.* 2017). A third study in 2017 captured

183 fish, 19% (34 adults) of which were untagged (Cathcart *et al.*). Razorback sucker stocked in the upper basin are typically adults with lengths >350 mm, but approximately 10,000 fish were released untagged in the San Juan River in 2006-2007. The fish released untagged were in distress and concern was expressed that they would not survive tagging. SJRIP tracks untagged fish in the San Juan River over time and saw an increase to almost 40% in 2006 (Table 11). Captures of untagged fish have lessened in recent years in the San Juan River, plateauing below 10% (Durst 2017). The untagged fish in Lake Powell do not prove recruitment is occurring, but the San Juan arm of Lake Powell is the only place in either basin where rates of untagged fish approach the levels documented in Lake Mead (59%) where recruitment is occurring (Albrecht *et al.* 2010). In addition, a single report documents the presence of 5 wild-recruited adults in the San Juan arm of the waterfall presumed to have been from 2008 and 2009 year classes (Barkalow and Platania 2017), but the results presented have not been widely accepted.

Table 11. Number and percentage of untagged Razorback Sucker razorback sucker captured by year in the San Juan River (Durst 2017).

	Individuals captured				
Year	Total	With PIT tags (stocked)	With PIT tags (tagged in field)	Without PIT tags	Percent without PIT tags
2004	415	381	0	34	8.2
2005	343	305	4	34	9.9
2006	561	340	8	213	38.0
2007	1104	707	40	357	32.3
2008	604	381	39	184	30.5
2009	698	439	75	184	26.4
2010	1117	873	80	164	14.7
2011	1713	1375	84	254	14.8
2012	2210	1797	96	317	14.3
2013	1927	1617	126	184	9.5
2014	1502	1256	118	128	8.5
2015	1827	1558	111	158	8.6
2016	1778	1519	105	154	8.7

In the Colorado River arm of Lake Powell (2014–2015), nearly 90% of fish are recaptures (Albrecht *et al.* 2017). Ongoing studies will assess whether the remaining 10% infers local recruitment or emigration from the San Juan arm or upstream rivers into the Colorado River arm. Razorback sucker are not currently stocked in Lake Powell, though many individuals stocked in the Green, Colorado and San Juan are captured or detected in the lake.

Razorback sucker movement between the San Juan arm and the Colorado River arm has been documented (Francis *et al.* 2015; Durst and Francis 2016), demonstrating that the populations within Lake Powell intermix, at least to some degree, and may warrant sampling and calculating lake-wide population estimates. Movement was documented during just a few days when lake levels increased sufficiently to allow for upstream movement of Lake Powell fish back into the San Juan River (Francis *et al.* 2015). Upstream movement of six individuals was documented (up to 180 miles up the San Juan River from Lake Powell), while downstream movement of fish stocked into the San Juan River was also documented (Francis *et al.* 2015; Durst and Francis 2016). Movement of Lake Powell razorback sucker among subbasins has also occurred. Between

2014 and 2017, 927 fish were documented in the Colorado River arm area (Francis *et al. In prep*). One-hundred fifty-two of them were captured in the same location in multiple years, 87 were reencountered in the Green subbasin, two were reencountered in the Colorado subbasin, and 27 were reencountered in the San Juan arm area (Francis *et al. In prep*). Razorback sucker in the San Juan River arm, much like what has been documented in the CRI and LGC (lower Grand Canyon), congregate at the base of the waterfall currently blocking movement into the San Juan River, indicating a preference for upward movement into the river. Additional efforts since these surveys have documented 716 individual razorback sucker at the San Juan River waterfall. At least 15 of those individuals moved from the Colorado River mainstem (Mark McKinstry, U.S. Bureau of Reclamation, personal communication, March 2018).

Genetic assessments indicate that allelic richness is higher in Lake Powell than in the Green or Colorado subbasins, with values approaching that of the lower basin (Dowling *et al.* 2012). Presence of other sucker species is limited, but flannelmouth sucker, bluehead sucker and flannelmouth x razorback hybrids have been found in both the Colorado and San Juan arms (Travis Francis, U.S. Fish and Wildlife Service, personal communication, May 2018).

In summary, the status of the population in Lake Powell is still very much in question and as a result, is grayed out in the current condition tables (Table 6 and Table 12). Population estimates in various areas of the lake show there are likely resident populations as well as transitory fish between Lake Powell and the associated river systems. Studies in recent years suggest that recruitment in this system may be occurring, but limited sampling efforts to date have been unable to confirm recruitment in Lake Powell. Additional sampling is planned to assess the condition of the population in the San Juan arm.

5.3.1.5 Summary of Current Demographic Conditions for Upper Basin Populations

Table 12. Summary of upper basin demographic current condition for razorback sucker (high condition is represented by green, medium condition by yellow, low condition by orange and extirpated condition by red). The gray box around Lake Powell is meant to indicate a lack of scientific data in comparison with other upper basin populations.

Population	Demographics					
	Adult population size (wild + stocked fish)	**Spawning and larval presence**	**Recruitment**	**Dependence on stocking**	**Genetic integrity (inbreeding or hybridization)**	**Population stability (wild recruited adults)**
Green River Subbasin (plus Lake Powell)	• Low precision estimate of 36,355 (95% CI: 17941-74854) stocked adults (2011-2013) up from a few 100 wild fish in the 1990's	• Spawning and egg production are documented annually since 1993 • Larvae are present and abundant in the river and have been increasing in recent years	• Juvenile recruitment has been documented consistently as a result of intense management actions. Juveniles were produced in Stewart Lake in 2013-2017, but have been difficult to track with current sampling efforts • Juveniles have been found in the lower Green River in multiple years, but sightings are rare • Adult recruitment is rare, some small adults have been found, but levels of untagged adults could be attributed to tag loss	• > 6,000 adults (average length >350 ml) are stocked into the Green River mainstem annually	• Genetic integrity is managed through stocking efforts, inbreeding has not been a concern • Hybridization with native flannelmouth sucker can occur; increased hybridization between White and native suckers may eventually increase risks to razorback sucker; white sucker are more likely to occur in cooler waters • Hybridization rates among all suckers have been increasing since 1980 in Lodore Canyon	• Wild populations are too low to measure • Stocked adult population is stable and increasing through annual augmentation efforts • Recent reports indicate that without continued stocking, populations are likely to decrease quickly
Colorado River Subbasin (plus Lake Powell)	• Basinwide estimates for 2013-2015 show an increasing population trend from 5035 (CI 95%: 3755-6315) to 8078 (CI 95%: 6731-9421), due entirely to survival of stocked individuals.	• Monitoring of early life stages is limited, a report is currently pending • Spawning has been documented in the Gunnison River and in the mainstem Colorado through the '15 and 18-mile reaches' • Presence during spring runoff suggests spawning in the Dolores River • Larvae are present, but widely-dispersed and low in number despite a strong stocking presence in the system	• Recruitment is rare, but juvenile presence has been documented • Three young-of-year fish were caught in 2012 and presence of one wild fish was found in one off-channel pond. In 2013, 39 juvenile sucker were caught in the Colorado (RM 83.9-14). • Untagged adults in the Colorado River are rare and are likely because of tag loss	• > 6,000 adult (average length >350 mm) are stocked into the Colorado and Gunnison rivers annually	• Genetic integrity is managed through stocking efforts, inbreeding has not been a concern • Hybridization with native flannelmouth sucker can occur; increased hybridization between White and native suckers may eventually increase risks to razorback sucker; white sucker are more likely to occur in cooler waters	• Wild populations are too low to measure • Stocked adult population is stable and increasing through annual augmentation efforts
San Juan River Subbasin (plus Lake Powell)	• Consistent estimates of approximately 3000 adults from Shiprock, New Mexico to Sand Island, Utah (approximately 70 river miles) • Almost entirely stocked individuals	• Spawning occurring annually • Successful spawners may be only 2% of adults, indicating a potential bottleneck • Larvae are present and abundant in the river, producing numbers comparable to other native sucker species • Larvae are present in the inflow areas of the San Juan into Lake Powell in small numbers • Larvae show higher levels of opercular deformities than other native species; the effects of which are unknown	• Some evidence indicates that limited juvenile recruitment is occurring, • Untagged adults in the San Juan River are rare and are likely because of tag loss	• 11,400 adults are stocked annually	• Genetic inbreeding has not been a concern • Hybridization with flannelmouth sucker can occur, but is rare • Successful spawners may be only 2% of adults, indicating a potential bottleneck	• Wild populations are too low to measure • Population is stable and increasing through annual augmentation efforts
Lake Powell (including inflow areas and the lake proper)	• San Juan arm: 667 (95% CI: 442–1,061) • Colorado arm: 2,184 (95% CI:1,748–2,713) • 572 ripe adults (SE = 11.7, 95% CI = 549–595) just below the San Juan Waterfall. • It is possible / likely that each arm of Lake Powell is an extension of the river above it (similar to LCRB populations), experts expect estimates are low and are investigating further	• Spawning and egg production has been documented at many sites • Larvae are present in small numbers from fish spawning in Lake Powell • Larvae are present in larger numbers in the Colorado arm	• Recruitment has not yet been definitively documented, but it is suspected at low levels • High percentages of adult fish are captured without tags, suggesting that recruitment to adult stages is occurring in the lake, but this has not been confirmed	• No stocking occurs in Lake Powell, but most individuals found in the lake were stocked in one of the three upstream river systems	• Inbreeding has not been a concern, genetic diversity is higher than in any other upper basin population • Few other sucker species are present, so hybridization is not a concern	• Status of this population is unknown • Further work is needed to examine whether this population should be considered independent or as integrated with upstream populations

5.3.2 Lower Colorado River Basin

In the LCRB, razorback sucker can be found from the lower Grand Canyon downstream to the Imperial Dam on the Colorado River, as well as in the Verde River in small numbers and with limited survival. More than 12 million razorback sucker have been stocked into the LCRB; their retention and survival were primarily restricted to reservoir populations and a few other populations found in the mainstem river, including backwater, and impoundment-type locations near Lake Mohave, Lake Havasu, and the Cibola and Imperial National Wildlife Refuges. The focus of reservoir stocking has moved towards stocking large adults and has resulted in adult survival, whereas the majority of early stockings focused on stocking juvenile fish that did not reach adulthood.

The LCRB is assessed as four individual populations: Lake Mead (including the Colorado River inflow/Grand Canyon), Lake Mohave, the Colorado River between Davis and Parker dams (Lake Havasu) and the Colorado River mainstem below Parker Dam.

5.3.2.1 Lake Mead

The razorback sucker population in Lake Mead is the only population in the Lower Colorado River Basin in which there is evidence of natural recruitment. The population apparently benefited from abundant habitat during the initial filling of the reservoir prior to a rapid decline that began in the 1970s (Albrecht *et al.* 2010). Based on data obtained from aging of 509 adults and subadults captured during 1996-2016, recruitment occurred in pulses during the 1980's (Mohn *et al.* 2017). Recruitment of wild origin razorback sucker was documented near annually in Lake Mead between the 1970's and the 1990's (Mohn *et al.* 2015). Reproduction and natural recruitment has been documented annually in turbid inflow areas (i.e., Las Vegas Bay, Echo Bay, and the inflow area of the Virgin and Muddy rivers) since the 1990s (Albrecht *et al.* 2010). Razorback sucker in the Lake Mead population migrate to and from upstream portions of the Colorado River, as evidenced by larvae captured and telemetry data collected during recent monitoring surveys in the Grand Canyon (Kegerries *et al.* 2017). Reliable estimates of the size of the Grand Canyon subpopulation have been elusive due to low numbers of PIT-tagged individuals recaptured in monitoring surveys, but growth rates and recruitment are indicative of a resident population (Mohn *et al.* 2015).

Despite the dominance of nonnative fishes in Lake Mead, razorback sucker continue to reproduce and recruit naturally on an annual basis (Albrecht *et al.* 2010; Mohn *et al.* 2015; Kegerries *et al.* 2015). Although documented predation of juvenile razorback sucker by nonnative fishes has occurred (Kegerries *et al.* 2015), predation and competition do not appear to be a limiting factor in the viability of the Lake Mead razorback sucker population but may limit the population size. Cover in the form of turbidity and submerged vegetation in inflow areas seems to be the key feature of Lake Mead that provides necessary conditions for survival and recruitment of larvae and juveniles despite the presence of a full suite of nonnative fishes (Albrecht *et al.* 2017). The population is likely to persist as long as these conditions are maintained.

Within the Lake Mead inflow areas 59% of individuals (325 adults) captured between 2010 and 2016 were new, wild, untagged fish (Albrecht *et al.* 2017). Razorback sucker in the Grand

Canyon appear to be rare, however, recent research shows movement of telemetered fish from Lake Mead into the lower Grand Canyon and limited captures of adult razorback sucker (Bunch *et al.* 2012; Albrecht *et al.* 2014; Rogowski and Wolters 2014; Kegerries *et al.* 2015). Additionally, razorback sucker spawning within the Grand Canyon or its tributaries was documented in 2014 and 2015 (Albrecht *et al.* 2014; Kegerries *et al.* 2015). It is unclear whether razorback sucker in the Grand Canyon are an extension of the Lake Mead population, but connectivity does exist between the two and therefore they will be considered a single population for the purposes of this report.

In Lake Mead, the CRI below the Grand Canyon, Virgin/Muddy River inflow area, and Las Vegas Wash provide spawning and recruitment habitat for razorback sucker. Reproduction is occurring annually and larval razorback sucker are being captured at all three locations (Kegerries *et al.* 2015; Mohn *et al.* 2015). Reproduction occurring upstream of Lake Mead in the CRI supplies additional larvae to the reservoirs via larval drift (Kegerries *et al.* 2015; Farrington *et al.* 2018).

In Lake Mead, trammel netting data from 2010-2017 yielded estimates between 400 and 600 individuals for Lake Mead and the CRI (Figure 24) (Albrecht *et al.* 2013a; Albrecht *et al.* 2014; Mohn *et al.* 2017). The recapture rate for that same time was 45% (Albrecht *et al.* 2013a, 2013b; Albrecht *et al.* 2014b). An estimate of annual apparent survival of 0.80 (95% CI=0.45–0.95) was derived from razorback sucker captures from 1996 to 2015 (Mohn *et al.* 2015).

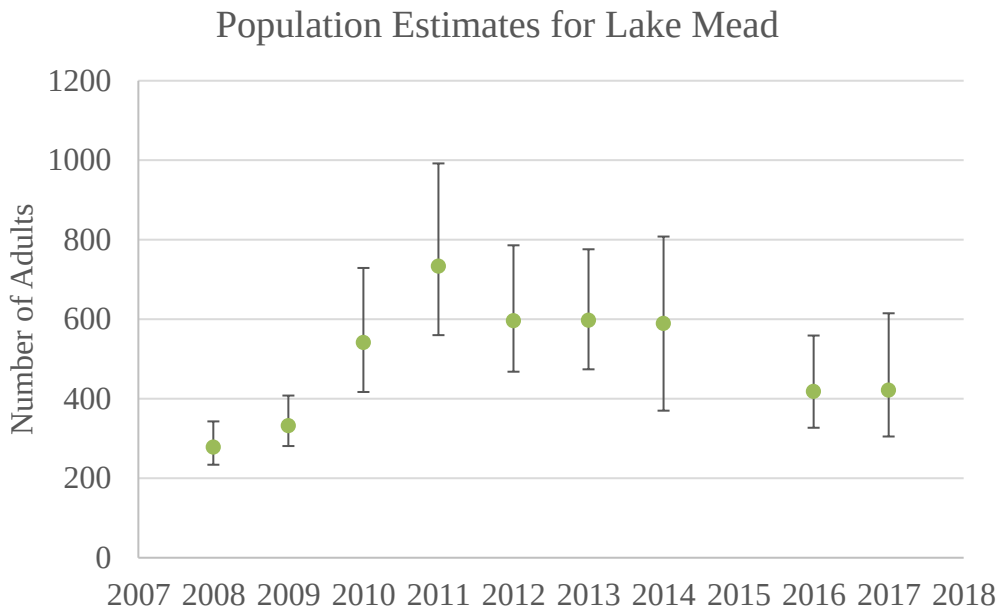


Figure 24. Razorback sucker population estimates for all individuals at large >1 year in Lake Mead by year, with error bars representing 95% confidence intervals.

In Lake Mead, razorback sucker movement among spawning areas during the spawning season and between years has been documented. More interesting still is movement into and out of Lake Mead by telemetered razorback sucker. From 2010 to 2012, three of five sonic-tagged razorback sucker moved from the lake proper at the mouth of CRI upstream into the mainstem river

(Albrecht, Kegerries *et al.* 2010; Kegerries and Albrecht 2011; Kegerries and Albrecht 2013). Additional sonic-tagged razorback sucker released both in the river and within the lake moved upstream and downstream, with some utilizing both the river and the lake annually. Sonic-tagged razorback sucker movement data to date shows use of the Grand Canyon from near Pipe Creek downstream into Lake Mead (Albrecht *et al.* 2014; Kegerries *et al.* 2015; BIO-WEST, unpublished data).

The Lake Mead razorback sucker population, although recruiting, is not as genetically diverse as the Lake Mohave population and shows variability in diversity and relatedness by spawning location and years. Persistent low population numbers are causing concern over genetic diversity and augmentation from Lake Mohave is being considered as a management action (James Stolberg, LCR MSCP, personal communication, July 2018).

In summary, Lake Mead is the only location where recruitment is occurring despite an abundance of nonnative fish. The population remains small which is causing concern about its long term persistence and the potential development of genetic bottlenecks. The LCR MSCP monitors the population regularly, but does not currently perform management actions to support the population.

5.3.2.2 Lake Mohave

The Lake Mohave population is supported by stocking of captive-reared fish from wild-spawned larvae and remains an important genetic refuge for razorback sucker. Approximately 60,000-75,000 naturally-occurring razorback sucker inhabited Lake Mohave during the 1980s, but the population declined to the point that fewer than 3,000 adults were thought to be present in the reservoir by 2001. The original wild population declined to less than 250 individuals by 2011 and has now been entirely replaced by adults that were reared in hatchery facilities and nearby grow-out ponds (Kesner *et al.* 2016).

Adult population estimates based on mark-recapture data involving PIT tagged fish recaptured during trammel net monitoring surveys were 2,230 individuals in 2015 (95% CI = 603, 3897), 1,707 (95% CI = 922, 5936) in 2016, 1,291 (95% CI = 531, 3436) in 2017 (Wisenall *et al.* 2015; Wisenall *et al.* 2016; Leavitt *et al.* 2017). Estimates using remote PIT scanning and mark-recapture models (Figure 25) were 3,572 individuals (95% CI 3,341-3818) in 2015 and 3,815 (95% CI 3,573-4,073) individuals in 2016 (Wisenall *et al.* 2015; Wisenall *et al.* 2016; Leavitt *et al.* 2017); indicating that continued stocking that began in the 1990s has preserved the population, but has not led to restoration of previous population levels (Marsh *et al.* 2003). The current population is made up of surviving individuals from stockings of more than 200,000 razorback sucker that were reared from larvae captured throughout the reservoir during the spawning season and transferred to hatchery facilities. Survival of stocked individuals is size-dependent, and adaptive management based on survival data led to an increase in the minimum size of stocked fish from 250 mm to 350 mm by 2004; and now > 500 mm TL is thought to be the optimal size for stocked individuals to escape predation by nonnative fish.

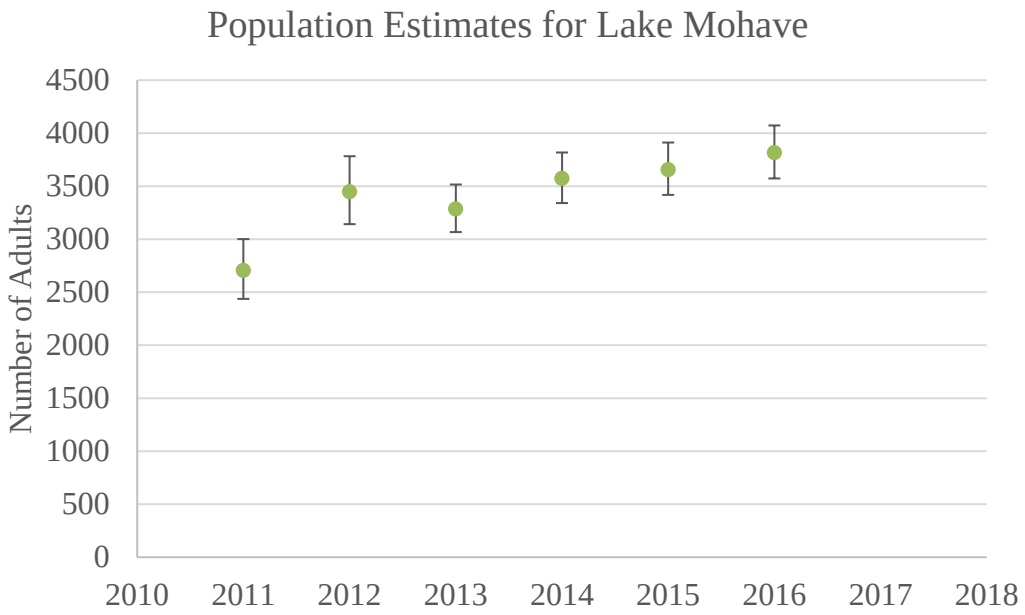


Figure 25. Razorback sucker population estimates for adults in Lake Mohave with error bars representing 95% confidence intervals from annual LCR MSCP surveys.

Spawning in nearshore areas possessing cobble and gravel substrates continues to occur, but there is very little evidence that wild larvae escape predation by nonnative fishes and recruit to juvenile sizes. A variety of nonnative fishes are known to prey on razorback sucker in Lake Mohave, with the larval stage being especially vulnerable (Kesner *et al.* 2016). Predation on larval razorback sucker by small centrarchids has been repeatedly observed during larval monitoring surveys, and consumption of eggs by channel catfish has also been observed. A recent study designed to detect razorback sucker DNA in nonnative fishes in Lake Mohave confirmed predation on larvae by all four centrarchid species that were sampled (Ehlo *et al.* 2017). Lake Mohave is a relatively clear and cool reservoir that lacks turbid inflow areas with submerged vegetative cover that are key spawning and juvenile habitats in Lake Mead. These habitats appear to be essential for natural recruitment.

The razorback sucker population in Lake Mohave represents the most genetically diverse but severely reduced wild population within the LCRB. Captive rearing of wild-spawned larvae allows managers to maintain genetic integrity, circumvent larval predation, and maintain the genetic variation of the population (Dowling *et al.* 2005). Currently, genetic diversity in Lake Mohave does not differ significantly between annual samples of stocked adult, larval, or wild razorback sucker (Dowling *et al.* 2013; Carson *et al.* 2016). Therefore, management efforts are achieving the goal of maintaining genetic integrity for razorback sucker in Lake Mohave.

Continued augmentation at present or increased levels of effort will be needed to stabilize the population at a size necessary to maintain genetic diversity. Transfer of adult razorback sucker in spawning condition to off-channel ponds adjacent to Lake Mohave would allow larvae and juveniles to reach maturity in predator-free environments (Minckley et al. 2003). To date, most studies have been restricted to ephemeral ponds, providing information on individual reproductive success. One permanent pond exists and progeny have recruited into the adult

population (Kesner *et al.* 2016). Expansion of this effort to create a series of off-channel habitats for exchange of adult razorback sucker with the reservoir has the potential to improve the efficiency of augmentation efforts at Lake Mohave.

5.3.2.3 Colorado River between Davis and Parker dams (Lake Havasu)

Razorback sucker are currently found from the inflow area of Lake Havasu up-river to the base of Davis Dam, representing one of the more successful reintroduction efforts within the LCRB (Wydoski and Lantow 2012), and demonstrating that recolonization of adult fish is possible after extirpation. The population of razorback sucker in Lake Havasu was created by stocking efforts after naturally-occurring razorback sucker had been extirpated from the area in 1986. More than 50,000 adults have been stocked in the reservoir and upstream portions of the Colorado River below Davis Dam since 2006, and the resultant population now numbers in the thousands (recent estimates range from approximately 2,500 to about 5,000 adult individuals (Figure 26) (Ehlo *et al.* 2015; Kesner *et al.* 2017). Trammel netting surveys and data from submersible PIT tag scanners have been used to monitor the population, but low numbers of recaptures have precluded precise abundance estimates. Survival rates of stocked razorback sucker appear to be similar to those at Lake Mohave, and vary with the size of the fish (> 350 mm TL have highest survival) and the date of stocking (Ehlo *et al.* 2015; Kesner *et al.* 2017).

Spawning activity has been documented, indicating that the population has the potential to provide larvae for hatchery propagation. This population has very limited potential for becoming a viable, self-sustaining population without recruitment, but could fulfill a role in serving as a refuge population maintained through augmentation, similar to the Lake Mohave population.

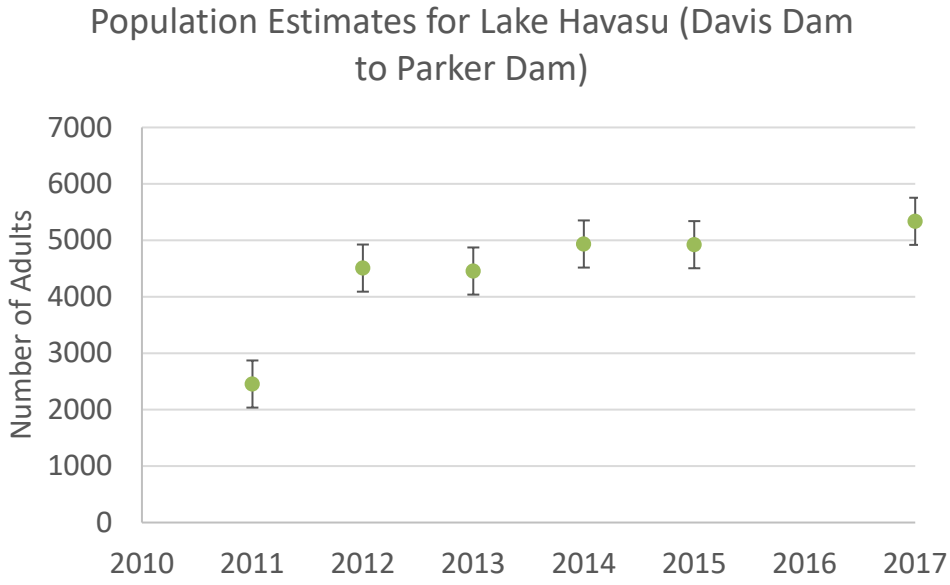


Figure 26. Razorback sucker population estimates of adults in lower Colorado River Reach 3 (Lake Havasu) using data from Kesner *et al.* (2017). Error bars represent 95% confidence intervals.

5.3.2.4 Colorado Mainstem below Parker Dam

Razorback sucker were historically abundant in reaches of the Colorado River below present-day Parker Dam, but the population rapidly declined and was nearly extirpated following the construction of mainstem dams and diversions. A few individuals were captured or observed in irrigation canals and reservoirs during the 1970s (W. L. Minckley 1983; Marsh and Minckley 1989).

More than 90,000 razorback sucker have been stocked between Parker and Imperial dams under the LCR MSCP between 2007 and 2017, 15,000 of which have been PIT-tagged (L. J. McCall *et al.* 2017). The PIT-tagged subset of razorback sucker were adult fish ranging from 275-640 mm TL; the stocking plan requires lengths >305 mm. Post-stocking survival of razorback sucker in this reach is poor; the largest fish stocked at >500 mm have an annual survival rate of 11% (Schooley *et al.* 2008). The primary cause of mortality is predation from piscivorous fish and avian predators. Tracking of released razorback sucker resulted in a population estimate of 216 adults (95% CI of 173, 271) in one backwater in the system (L. J. McCall *et al.* 2017). No estimates of in-river populations have been completed to date.

Senator Wash Reservoir is an off-channel reservoir in California used for pump-back water storage for irrigation located approximately two miles upstream from Imperial Dam where a substantial number of razorback sucker were entrained following its creation in 1966 (W. L. Minckley 1983). Razorback sucker are currently known to exist in Senator Wash Reservoir, due in large part to stocking efforts. In 2003-2004, populations were estimated to be 280 fish (95% CI of 212-400) (Kretschmann and Leslie 2006). Spawning behavior was observed but larvae were absent possibly due to high predation or reservoir operations, which may be drying eggs. Natural recruitment appears to be lacking (Kretschmann and Leslie 2006). Senator Wash Reservoir water elevations vary both diurnally and seasonally and the reservoir is home to a variety of nonnative fish, including flathead catfish, channel catfish, striped bass, threadfin shad *Dorosoma petenense*, largemouth bass, common carp, and various sunfish species (Kretschmann and Leslie 2006). Senator Wash Reservoir is not actively managed for razorback sucker, and currently there are no ongoing stocking efforts. At this time, the status of the razorback sucker population in Senator Wash Reservoir is unknown.

Although this section of river contains complex habitat (vegetation, backwaters and some turbidity), the prevalence of nonnative fishes in the portion of the Colorado River between Parker Dam and Imperial Dam are likely to prevent the establishment of a stable and viable population unless management actions are taken to create areas of favorable environmental conditions. River reaches downstream from Imperial Dam are even more unsuitable as razorback sucker habitat, because of extensive dewatering and channelization.

5.3.2.5 Additional areas

In the Gila River system, razorback sucker have been stocked in the Verde, Gila, and Salt rivers and their tributaries where the natural population had been extirpated (Hendrickson 1994). From 1991 to 2004, nearly 23,000 razorback sucker were stocked in the Salt and Verde rivers. The majority of stocked fish were smaller in size when compared to fish stocked into the mainstem Colorado River. Because only 285 of those fish were ever recaptured, survival of stocked fish is

assumed to be low (Hyatt 2004). In the Verde River, numerous fish have been recaptured, and survival of up to six years has been documented. In addition, ripe males were encountered in the Verde River, but no evidence of reproduction or recruitment was found (USFWS 2002). Razorback sucker were stocked into Fossil Creek (a Verde River tributary) during at least two periods with limited success and retention. Razorback sucker were stocked into Fossil Creek near Fossil Springs and near Irving, Arizona during October 1988. A few were observed during subsequent surveys in 1989 (Weedman *et al.* 2005). Some of the razorback sucker stocked in 1988 ended up in Stehr Lake where they persisted until they were removed during the salvage operation before the 2004 chemical treatment (Weedman *et al.* 2005). From 2008 to 2014, 4,076 razorback sucker were stocked into Fossil Creek (Love-Chezem *et al.* 2016). Larger individuals were stocked in 2008 (mean 295 mm TL), slightly smaller in 2009 (127-278 mm TL), and the 2,500 stocked in 2014 were largely <100 mm TL. During monitoring, only a few razorback sucker were observed in 2008 and 2009, and none were detected in 2010, 2011, 2013, 2014, or 2015 (Love-Chezem *et al.* 2016). Post-stocking downstream movements, along with Southwestern river otter *Lontra canadensis sonora* predation, suggests unfavorable habitat conditions within Fossil Creek for razorback sucker.

Survival rates in the Gila River basin appear to be low due to predation by nonnative fishes and altered habitat. Naturally occurring adult razorback sucker persisted in the Verde River until at least 1954, but young juveniles were last collected in the Gila River drainage in 1926 (Minckley 1983) and there has been no definitive evidence of reproduction or recruitment since that time. A few stocked individuals appear to have persisted for several years based on capture data from Horseshoe Reservoir, on the lower Verde River, and at Fossil Creek (Weedman *et al.* 2005). Had there been continued large scale stocking efforts in the Gila River it is not unreasonable to think that a similar situation that exists in the lower Colorado River below Hoover dam could exist in the Gila River basin. Because of the lack of survival of stocked fish and lack of recruitment, the areas in the Gila River basin have not been assessed as populations in this SSA.

5.3.2.6 Summary of Current Demographic Conditions for Lower Basin Populations

Table 13. Summary of lower basin demographic current condition for razorback sucker (high condition is represented by green, medium condition by yellow, low condition by orange and extirpated condition by red).

Population	Demographics					
	Adult population size (wild + stocked fish)	**Spawning and larval presence**	**Recruitment**	**Dependence on stocking**	**Genetic integrity (inbreeding or hybridization)**	**Population stability (wild recruited adults)**
Lake Mead (including Grand Canyon)	• 2017 Estimate: 421 (305-615) • 2014-2016 Estimates: Nets: 418 (327-559) Antennas: 589 (370-808)	• Spawning occurs annually at multiple locations in Lake Mead proper (Echo Bay, Las Vegas Bay, Virgin/Muddy river inflows) and in Grand Canyon • Spawning occurs across a broad temporal period (February to May) • Larvae are found throughout Grand Canyon downstream of Havasu Creek, well dispersed (in spatial extent) but not documented in large numbers	• Occurring annually in the lake • 59% of the fish caught in the lake are unmarked, indicating high levels of recruitment • Untagged adult fish have been caught in the Grand Canyon, but their origin is unknown • No juveniles have been documented in the canyon, but are periodically captured in Lake Mead.	• Least augmented population in either basin • Fish are not commonly stocked in Lake Mead, small numbers of fish have been introduced to increase genetic diversity or to track specific fish movement • 70-80% survival in the lake	• Less diverse than Lake Mohave and Lake Havasu populations • Genetic variation changes annually • Small subpopulations have potential for inbreeding • Hybridization with flannelmouth sucker documented in Grand Canyon and inflow area	• Population is stable at low population levels, after a sharp decline occurred during the 1970's and 80s
Lake Mohave (including all river below Hoover dam) LCR MSCP Reach 2	• 2017 Estimates: Nets 1291 (531-3436)* Antennas 3815 (3573-4073) • 2016: Nets 1707 (603-3897)* Antennas 3572 (3341-3818) All repatriated individuals	• Spawning and egg production occur annually in multiple locations throughout the system (known spawning locations are separated by 5, 8 and 30 miles) • 18,000-35,000 larvae collected annually throughout the spawning season for hatchery rearing and future repatriation. Spawning occurs across a broad temporal period (late Jan to May)	• Undocumented, if occurring, expected to be minimal • Untagged adults in in this reach are rare and are likely because of tag loss	• Wild larvae are collected on an annual basis and raised in hatcheries, then returned to the river • 8,000 adults are repatriated annually (>400 mm) • 90% survival rates for adults at large in the reservoir for more than 2 years	• Highest levels of genetic diversity documented for the species	• Wild population is assumed extirpated; no wild adults have been documented. • Population is relatively stable in the presence of active augmentation • Populations have declined from historic highs, despite augmentation
Lake Havasu (below Davis dam to Parker dam) LCR MSCP Reach 3	• 2017 Estimate: 5337 (5043-5633) • Largest population in the LCRB All stocked individuals	• Spawning and egg production occur annually in multiple locations throughout the system • Larvae are present	• Undocumented, if occurring, expected to be minimal • Untagged adults in this reach are rare and are likely because of tag loss	• 6,000-12,000 adult fish are stocked annually • Fish stocked at 350 mm have a survival rate of 10%, but event survival was as high as 58% with large fish released in small batches	• Diversity similar to Lake Mohave • Hybridization may occur with flannelmouth sucker, but not documented at levels seen in Lake Mead	• Wild population is assumed extirpated; no wild adults have been documented. • Population is stable and may be increasing, but consists of stocked/repatriated adults
Colorado Mainstem Below Parker Dam LCR MSCP Reaches 4 & 5	• Survival in these reaches is low; there are not enough fish to develop a population estimate	• Low-level spawning and egg-production observed in backwater habitat at Senator Wash Reservoir and various backwaters in Blythe, California • Larval presence confirmed in backwater habitat in 2017	• No evidence of natural recruitment • No untagged adults have been found in this reach	• 6,000-12,000 fish per year are stocked from Bubbling Ponds (SNARRC) in this segment • Survival of stocked fish remains low, with largest stocked fish (>500 mm) surviving at rate of 11%	• Genetic integrity is managed through stocking efforts, inbreeding has not been a concern	• Population is not stable and only maintained by stocking

5.4 Current Species Viability

As noted in the introduction, species viability is related to the species' ability to withstand stochasticity (resiliency), the ability to withstand catastrophic events by spreading the risk among multiple populations (redundancy) and the ability to adapt to changing environmental conditions (representation). An assessment of each of three R's (resiliency, redundancy and representation) provides an assessment of the species' ability to persist in the wild.

5.4.1 Resiliency

Razorback sucker are adapted to a wide variety of ecological conditions found throughout the Colorado River basin. Populations in the upper basin are primarily lotic; populations in the lower basin occupy both lotic reaches and reservoirs created for water storage and management in the past 50-70 years. Razorback sucker prefer cobble or rocky substrate for spawning, but have been documented to clear sediment from cobble and even spawn successfully over clay beds. Juveniles and adults have access to appropriate habitat throughout the system ranging from backwaters and floodplains to deep and slow moving pools, however nonnative fishes are frequently found in such habitats as well. The species is tolerant of wide-ranging temperatures, high turbidity and salinity, low dissolved oxygen and wide ranging flow conditions. Razorback sucker consume a variety of food items, based on their occupied habitat. Razorback sucker typically become sexually mature between 3-4 years, and can live for more than 40 years. Once adults have recruited into the system, they can persist for many years and spawn multiple times. Recruitment continues to be functionally nonexistent across the basin primarily because of a persistent presence of nonnative predators and lack of rearing habitat, compromising resiliency of most populations.

When both habitat and demographic conditions for each population are averaged to represent resiliency, all populations fell into the medium (2) condition with the exception of the Colorado River below Parker Dam, which resulted in a low (1) condition (Table 14).

Table 14. Summary of current condition, averaged with all species needs (habitat and demographic factors) and demographic factors only. On a scale of 0 (extirpated) to 3 (high condition) an average value of 0-0.75 represents extirpated condition, 0.76-1.5 is low condition, 1.51-2.25 is medium condition and 2.26-3 is high condition. The limiting demographic need column provides the lowest demographic categorization per population to show limiting factors.

Population	Average of Habitat and Demographic Needs	Average of Demographic Needs Only	Limiting Demographic Need
Green River subbasin	2.2	1.8	1
Colorado River subbasin	1.8	1.3	0
San Juan River subbasin	1.8	1.3	0
Lake Powell	2.0	1.5	1
Lake Mead	2.2	2.5	1
Lake Mohave	1.7	1.5	0
Lake Havasu	1.7	1.3	0
Colorado River below Parker Dam	1.1	0.5	0

When only demographic conditions for each population are averaged to represent resiliency, one population is in high condition (3), one population is in medium condition (2), five are in low condition (1) and one is in extirpated condition (0) (Table 14 and Figure 27). As seen in the condition category tables above (Table 4 and Table 5), different definitions were developed to categorize each aspect of resiliency on a high to extirpated scale. In the following section, we average the conditions across the categories to provide an overall assessment of resiliency. We acknowledge this is not a scientific assessment, but an attempt to develop a tool that can easily communicate the differences among populations.

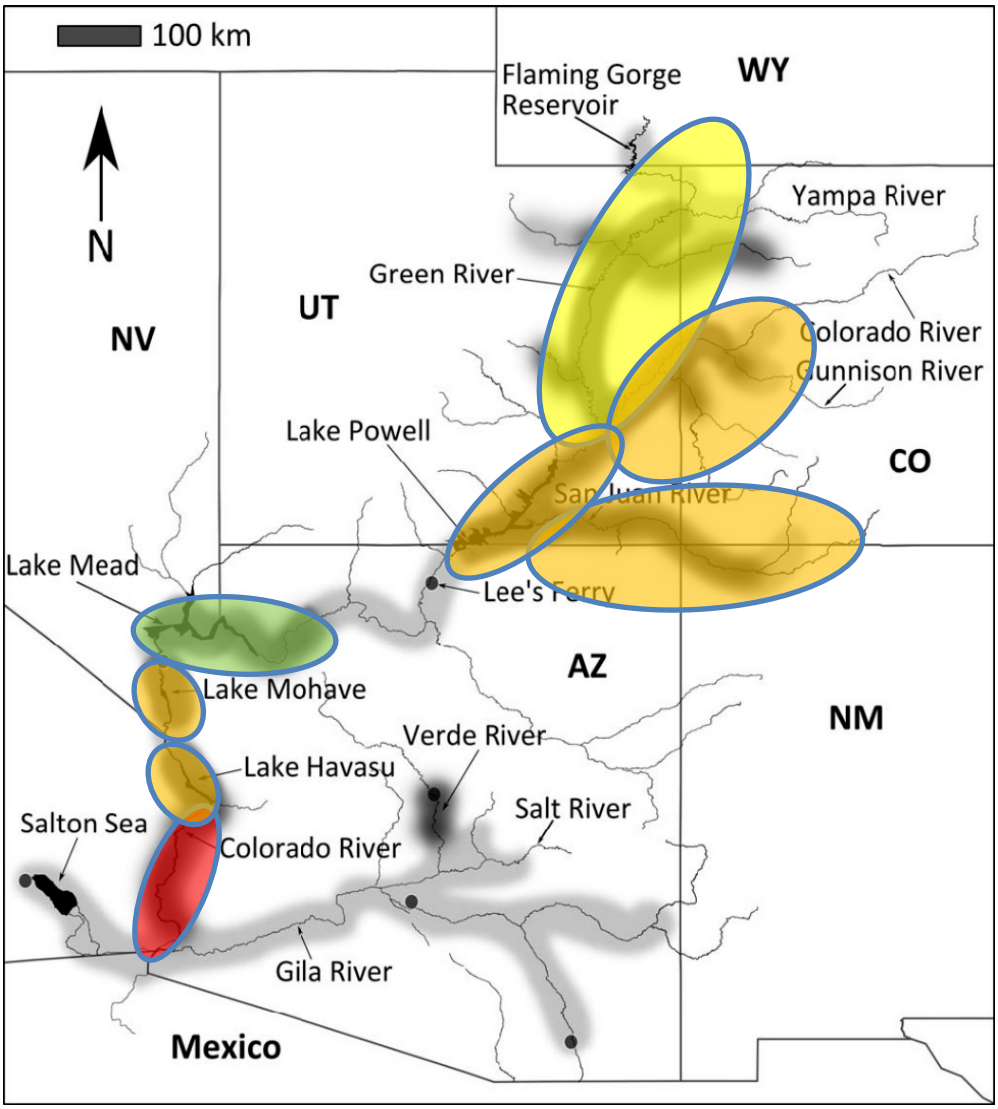


Figure 27. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing an average of current condition of demographics. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

In the upper basin, juveniles have been captured at very low levels in some years. The management of floodplain wetlands in the Green River has shown that juvenile recruitment is possible when large-bodied nonnative fishes are excluded from juvenile habitat and habitat conditions are maintained, which increases the resiliency of this population. Accessibility of floodplain habitats to larvae has been improved through management of peak dam releases timed to coincide with larval drift. Managing floodplains to increase juvenile recruitment is labor intensive, including filling and draining the wetlands, excluding nonnative fish, managing cattails and other vegetation and maintaining water volume and quality. Adult recruitment has only been documented in Lake Mead, but evidence suggests that it may also be occurring to some extent in Lake Powell. In the lower basin populations, nonnative fishes are a dominant presence preventing detectable recruitment in all populations except Lake Mead.

Although the species is resilient to a variety of environmental conditions, nonnative predation is preventing significant recruitment from occurring in most populations, dramatically reducing the resiliency of the species. Loss of floodplain habitat and connectivity is also limiting populations in the upper basin. The population in Lake Mead is currently the only population with natural ongoing recruitment, and has shown a high degree of resiliency by persisting despite a heavy nonnative fish presence. However, the Lake Mead population size is persistently low which presents a high risk for failure. Lake Mohave's population relies on collection of larvae, growth in off-channel predator-free ponds and reestablishment of adult fish to avoid predation of juveniles in areas dominated by nonnative fish. More traditional stocking techniques have been successful in maintaining the population in Lake Havasu, but populations have not established below Parker Dam. Currently, all populations (except Lake Mead) are dependent on active stocking because of a lack of recruitment and self-sustainability. Without continued management actions (primarily stocking), the resiliency of all populations other than Lake Mead would likely be in an extirpated condition.

5.4.2 Redundancy

Razorback sucker are present in populations spanning the entire Colorado River basin, exhibiting a high degree of redundancy. The species is expected to survive localized, and even regional catastrophic events such as fire and drought. Despite the presence of major mainstem dams, razorback sucker occupy much of their historic habitat and are distributed across six states in both rivers and reservoirs. However, current population densities are lower than have been documented historically. The four upper basin populations are connected and individuals have transitioned between them (with the exception of fish moving into the San Juan). Razorback sucker in the Green and Colorado subbasins use a variety of tributaries, either year round or seasonally (in some cases for spawning). Individuals have been documented to move hundreds of miles through multiple upper basin populations. Documented movement data strongly suggests that individuals from nearby, unaffected reach would quickly recolonize local extirpations. Redundancy of populations is dependent on stocking.

Lake Mead, Lake Mohave and the Colorado River between Davis Dam and Parker Dam (Lake Havasu) span hundreds of miles and have high internal redundancy as well – meaning fish are not concentrated in a single area but instead reside in several locations throughout each reservoir and associated inflows. As noted above, the lower basin populations exist in locations dominated

by large-bodied nonnative predators, which puts them at some risk. If stocking was discontinued, we expect populations would dwindle and disappear from Lake Mohave and the Colorado River between Davis Dam and Parker Dam (Lake Havasu).The Colorado River downstream of Parker Dam contributes little to redundancy despite active stocking efforts.

5.4.3 Representation

Razorback sucker have shown a high degree of plasticity in their ability to inhabit both lotic and lentic habitats. After populations were dramatically reduced in the upper basin, stocked individuals have displayed the ability to migrate, presumably for spawning purposes. Genetics of upper and lower basin populations have been assessed; results reveal healthy amounts of diversity and little reason for related concerns. Lower basin populations, especially in Lake Mohave, exhibit higher genetic diversity and less relatedness than upper basin populations (Dowling *et al.* 2012). For this reason upper basin broodstock managers incorporated a relatively small amount of lower basin genetics. Upper basin broodstock have always been used for upper basin augmentation efforts.

Some hybridization occurs with other native and nonnative suckers, but currently only at low levels. Genetic representation both within and among populations is thought sufficient because it is being managed in hatcheries. Genetic adaptability will remain low as long as population level recruitment and self-sustainment is missing, and populations are dependent on stocking. Natural recruitment (and selection), currently lacking in most populations, will be a necessary component of genetic adaptability in the future.

6 FUTURE CONDITION AND VIABILITY

6.1 Expert Elicitation

6.1.1 Assessment of Multiple Generations

We used a Delphi process to quantify factors most likely to affect razorback sucker in the future, including risk and conservation factors in the analysis. The Delphi process draws on a panel of experts to forecast probable outcomes using a series of questionnaires and a structured feedback process (Dalkey and Helmer 1963; Linstone and Turoff 1975; Hsu and Sandford 2007). The Delphi technique has been applied successfully to a variety of environmental analysis contexts for more than 50 years. Typically, the process involves at least two rounds of scoring by the expert panel with group feedback provided between scoring rounds. The process used here (full methods and results in Appendix A) involved three rounds of scoring to identify both risks and conservation actions for the razorback sucker across the populations in both upper and lower basins. In the first Delphi round, participants were asked to rank and weight a list of factors and subfactors potentially influencing the near-term viability of razorback sucker (within the next 30 years). In the second round, each participant was sent a customized report indicating how their weightings compared with the group response. The report flagged any individual's factor and subfactor weightings that were higher or lower than the group average by one standard deviation. Each participant was asked to comment on their higher and lower weightings, as well as to provide any other observations that they wanted to share. In the third round, participants were asked to consider the comments and reweight each factor and subfactor (they could keep the existing weight or select a higher or lower weight based on their reaction to comments).

For the purpose of this assessment, a period of approximately 9 years into the future was considered one-generation time for the species. Generation time (GT) is the average interval of time between the birth of parents and the birth of their offspring, or the average time for a population to increase by a factor equal to the net reproductive rate (Seber 1982; M. Gilpin 1993). It was computed as:

$$GT = age_{sSM} + (1/d)$$

where: age_{sSM} = average age at sexual maturity, and
d = death rate.

Generation time for the razorback sucker was computed from an average age of sexual maturity of approximately 4 years and an annual adult mortality or death rate (based on the wild Lake Mead fish survival rate as described by Mohn *et al.* 2015) of 1 – 0.80 = 0.20; i.e., 4 + (1/0.20) = 4 + 5 = 9 years.

6.1.2 Assessment over 30 Years

For the purpose of this SSA, USFWS assesses the future time frame as 30 years into the future, representing 3+ generations. The USFWS finds this length of time to be biologically meaningful but also foreseeable as there is sufficient uncertainty regarding impacts of changes in streamflow,

potential modifications to water temperature, nonnative fish predation and competition, and ongoing human demands for water.

Participants were asked to rank the risk and conservation actions most impactful to razorback sucker over the next 30 years (approximately three generation times). Participants ranked eight major categories of factors in perceived order of importance and assigned each factor a weight out of 100 total points. They were then asked how they thought risks and conservation measures would change beyond that (30-100 years).

The future condition of razorback sucker habitat and species demographics are intrinsically linked to stream flow and water temperature, both of which are affected by human water demand and climate change and nonnative species. Participants weighted nonnative predation as the most influential factor over the next 30 years, followed closely by two habitat-influencing factors: flow regime and water management (Figure 28). Comparison of the error bars for each factor illustrate that there were no significant changes in mean weighting from Round 1 to Round 3, which was also confirmed by ANOVA tests (ANOVA, $p<0.05$ for all factors). In addition, there were no changes in the rank order of mean weights between scoring rounds.

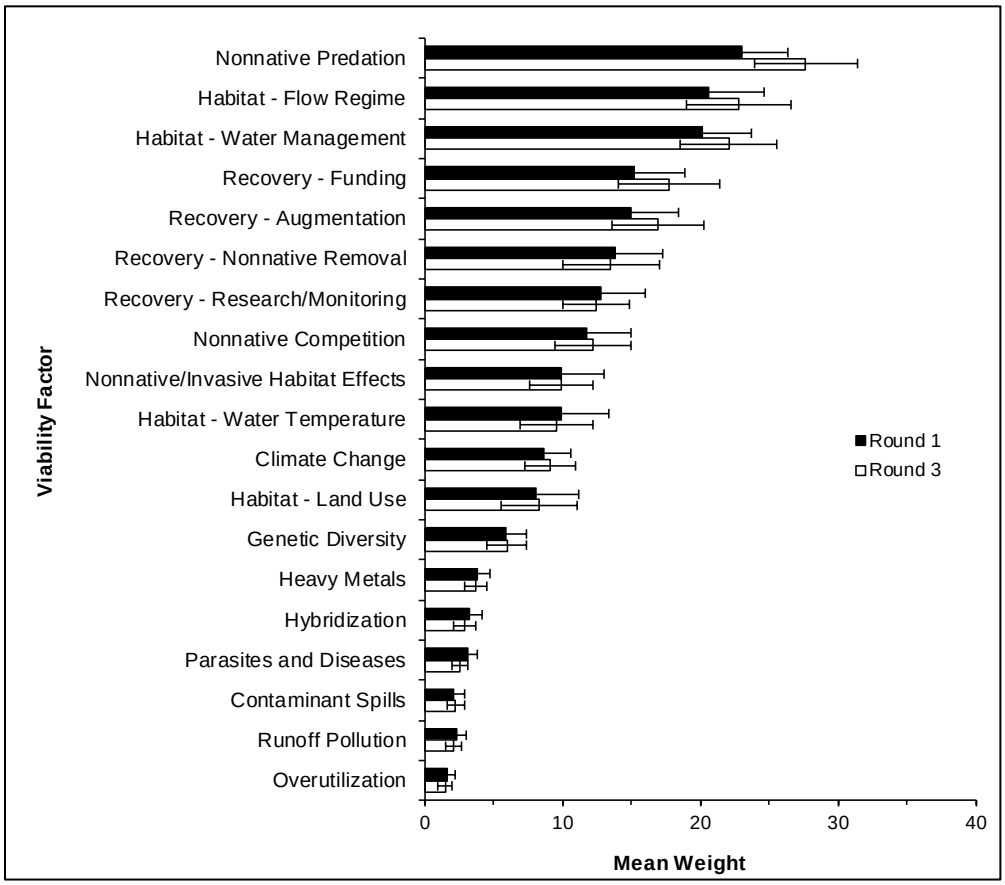


Figure 28. Mean weights of importance (out of 100 total points) assigned to factors potentially influencing viability of razorback sucker during the next 30 years (± 2 Standard Errors) as assessed by the Delphi participants

The most noticeable change was an increase in weights assigned to the five top-ranked factors, with nonnative predation receiving the largest increase in weight. However, variability in

weights assigned to the most influential factors remained high in Round 3, as indicated by measures of variation remaining higher for the top-weighted factors compared with the lower-weighted factors. Statistics indicating variability in weightings (the interquartile range and the minimum and maximum weights) suggest that there were higher levels of agreement regarding the less influential factors. In particular, the interquartile range was less than 10 for genetic factors (genetic diversity and hybridization), pollutant factors (heavy metals, runoff pollution, contaminant spills), parasites and diseases, and overutilization, indicating that at least half of the participants weighted these factors within 10 points of one another.

Based on a consideration of post hoc comparisons (Table 15), the factors were grouped into four tiers of influence in the following manner:

- In the top tier of influence are the three factors that the group weighted highest: nonnative predation and the top two habitat-influencing factors, flow regime and water management (shown as Shared Group A in Table 15). Mean weights for these three factors all exceeded 20 in the Round 3 results.

- The second tier primarily includes conservation and recovery efforts: program funding, augmentation, nonnative removal, and research and monitoring. The group's mean weights for these factors ranged from a high of 17 to a low of 12 (shown as Shared Group C in Table 15). Nonnative competition was also included with this tier at the lower end of the range with a mean weight of 12.17.

- The third tier consists of secondary factors that are related to the top tier of factors; these are habitat-quality influencing factors with mean weights between 10 and 3 (shown as Shared Group E in Table 15). These factors include habitat effects of nonnatives, water temperature, climate change, land use, and heavy metals. Genetic diversity is also grouped in this tier.

- In the fourth tier are the factors that the group assessed as being the non-influential factors, at least at the species scale: hybridization, parasites and diseases, contaminant spills, runoff pollution, and overutilization. These factors all had mean weights less than 3 (shown as Shared Group H in Table 15). Some participants thought that some of these factors were being underrated by the group or that these factors may have effects for some localized populations, such as hybridization, runoff pollution, and risk of contaminant spills.

Table 15. Post-hoc, all-pairwise comparison analysis based on Tukey's honest significant differences test, Round 3 group weights.

Factor	Mean Weight	Homogeneous Groups[a]*	Shared Group [a]
Nonnative Predation	27.64	A	A
Habitat - Flow Regime	22.77	AB	A
Habitat - Water Management	22.04	AB	A
Recovery – Funding	17.68	BC	C

Recovery – Augmentation	16.92	BC	C
Recovery - Nonnative Removal	13.52	CD	C
Recovery - Research/Monitoring	12.47	CD	C
Nonnative Competition	12.17	CD	C
Nonnative/Invasive Habitat Effects	9.85	DE	E
Habitat - Water Temperature	9.53	DE	E
Climate Change	9.09	DEF	E
Habitat - Land Use	8.28	DEFG	E
Genetic Diversity	5.94	EFGH	E
Heavy Metals	3.67	EFGH	E
Hybridization	2.94	FGH	H
Parasites and Diseases	2.55	GH	H
Contaminant Spills	2.22	GH	H
Runoff Pollution	2.07	GH	H
Overutilization	1.45	H	H

[a] Letters denote groupings of factors in the post-hoc test, with significantly different scores indicated by each letter.

Participants were also asked to rate factors and subfactors by basins on a 1–5 scale. A sensitivity analysis was completed to compare the influences between the upper and lower basin. The relative weight of each factor (Figure 29) indicates which basin is predicted to be more impacted by that risk. If participants made no distinction between the UCRB and LCRB for a given factor, then that factor would have a mean relative weight of zero. In many cases, the error bar overlaps zero, reflecting variability in ratings among participants.

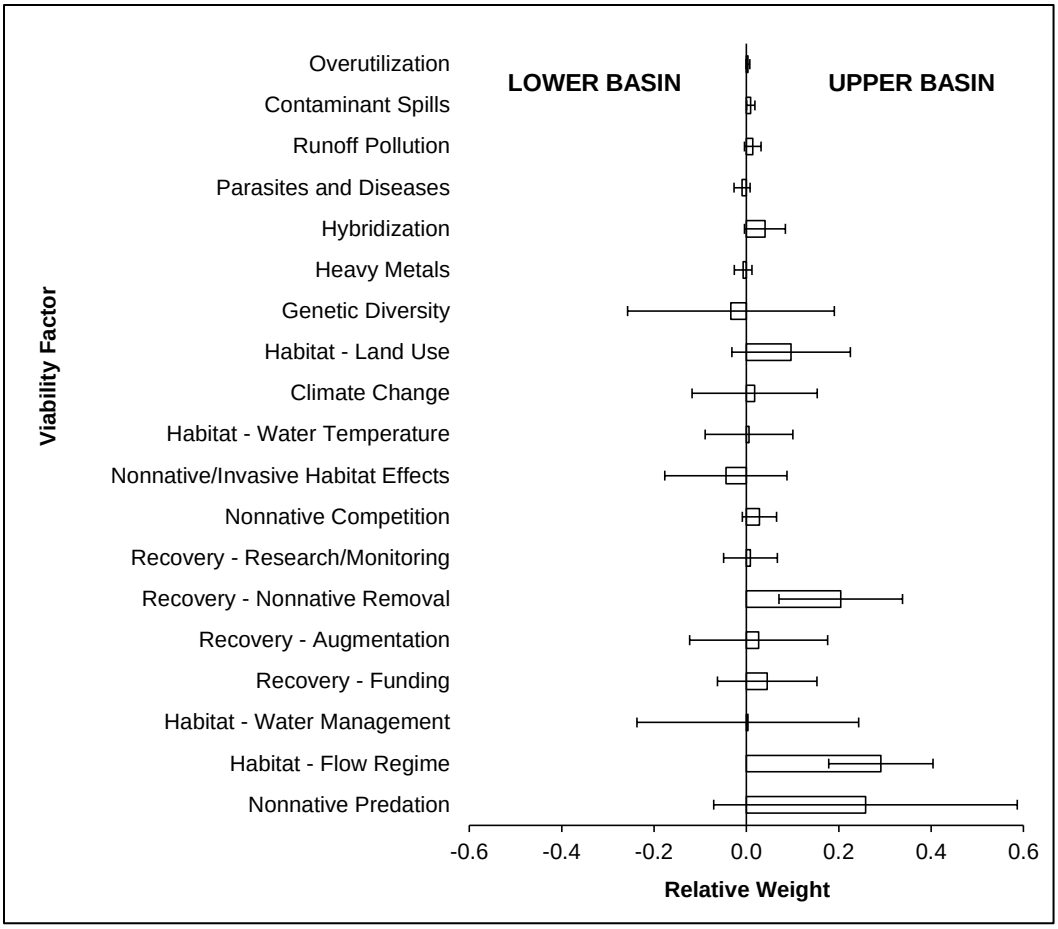


Figure 29. Mean relative weight of factors for the continued Razorback Sucker population viability in the UCRB and LCRB Round 3 (± 2 Standard Errors), as determined by the expert panel (± 2 Standard Errors). Wider bars indicate greater differences in impact between the upper and lower basin.

Looking at all of the factors (Figure 29), the only ones that do not have error bars overlapping zero are flow regime and nonnative removal; thus, participants rated these factors as being more influential in the UCRB. Factors that were perceived as a little more influential in the LCRB were habitat effects of nonnative/invasive species, genetic diversity, heavy metals, and parasites and diseases, but all have standard errors that cross zero.

6.1.3 Longer-Term Assessment (30-100 years)

Participants were asked to rate whether they thought that major categories of factors would become more or less influential 30–100 years in the future in relation to over the next 30 years. Participants were asked to rate the major factor categories (not subcategories) on a 1–5 scale with 1 representing “less influential,” 3 representing “same influence” and 5 representing “more influential.” As with the previous assessments, participants rated these factors in Round 1, provided comments regarding their ratings in Round 2, and then had the opportunity to update their ratings in Round 3 based on review of the comments provided by others. As is evident from the error bars in Figure 30, variability decreased for all of the long-term factor ratings in Round 3 and the group averages shifted slightly. None of the factor averages changed mean ranked order from Round 1 to Round 3.

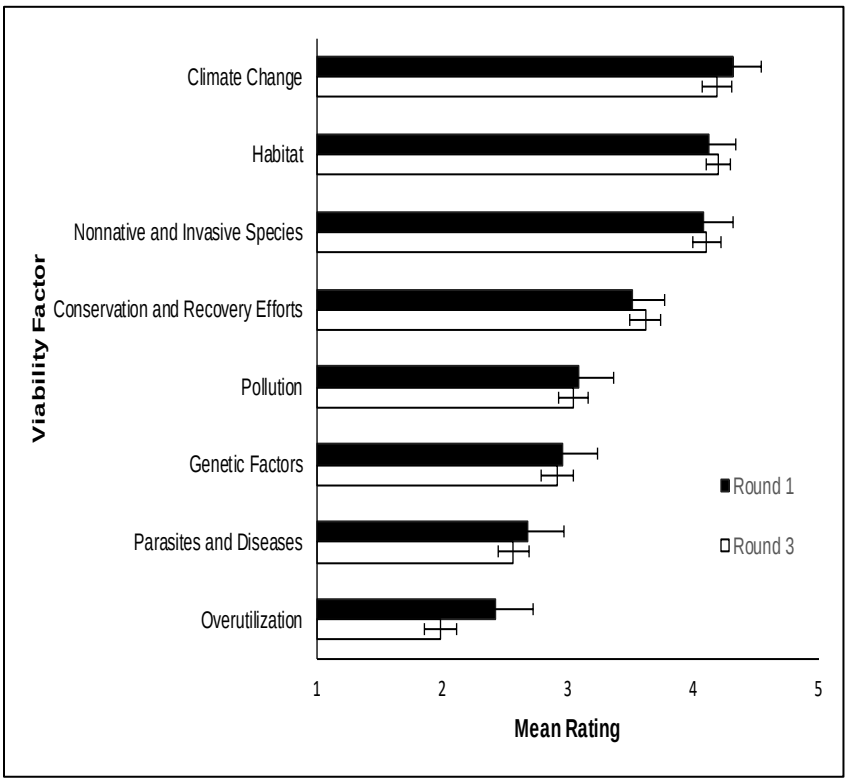


Figure 30. Mean ratings of expected change in influence on viability in 30–100 years on a 1–5 scale with 1 representing "less influential," 3 representing "same influence," and 5 representing "more influential" (±2 Standard Errors).) over the longer period as assessed by the Delphi participants.

Participants expected climate change to become more influential in the 30–100 year period than during the next 30 years. Participants rated habitat and nonnative species as highly influential in the near term and expected these factors to become more influential in the long term.

The mean rating for climate change decreased slightly from Round 1 to Round 3 (Figure 30). In Round 2, participants were asked to provide comments for any of their ratings that were one standard deviation higher or lower than the group's average rating. Those who did not rate climate change as increasingly influential in the 30–100 year period (a rating of 3) explained their rating based on greater than expected resiliency and adaptability of razorback sucker at the present time, the broad geographic range of the species, and its apparent adaptability to historic climate variability and stochastic events through its evolutionary history. Others thought climate change may have some positive effects such as providing warmer water where it is presently too cold or possibly improving habitat as a result of earlier spring flows in some locations. While there was a slight decrease in the group's average rating of climate change in Round 3 (mean = 4.2, standard deviation = 0.7), the majority of participants continued to rate climate change as becoming more influential 30–100 years in the future.

Participants also expected conservation and recovery efforts to continue to influence long-term viability, having the same or an even greater influence beyond 30 years from the present. Thus, participants were not particularly optimistic that razorback sucker would become independently viable in the long term, with wild recruitment being referenced as the necessary element to

ensure viability. Pollution and genetic factors were expected to have the same long-term potential influence as these factors would have in the nearer term. Parasites and diseases and overutilization were not expected to be longer-term influences and would possibly become even less influential in the 30–100 year time frame as rated by the participants.

This assessment of the 100-year period is used in a limited manner in this SSA because of the difficulty in predicting conditions over that time frame. It is used only in providing the Science Team's probability assessment of the various scenarios over a longer time frame but is not assessed specifically in future scenarios.

6.2 Future Environmental Condition

Based on the Delphi process, the Science Team developed a range of future scenarios, limited in scope to the most influential risks and conservation actions (Figure 31). The goal of scenario development was to take the most influential factors and predict how they are likely to affect razorback sucker populations over the next 30 years. The scenarios developed by the Science Team were based on a probable range of conditions in the top two tiers of influential factors from the Delphi process (Appendix B). This process was qualitative in nature and is meant to be a summary of their best scientific judgement.

Over the past 30 years, management actions have increased and/or supported populations across the Colorado River basin and have, in many cases, developed the populations currently in place through active intervention. Because of the reliance of this species on continued management, the scenarios represent different levels of management action or intervention in the system and their subsequent effect on the populations based on the effectiveness of those management actions. All scenarios assume higher water temperatures and lower water availability in the system as a whole based on the research presented in section 4.1.

- Scenario 1 – Scenario 1 represents a dramatic decrease in conservation and recovery actions resulting from the elimination or reduction of programs authorized to carry out such actions or the funding that supports them. This scenario assumes an elimination of some active recovery and adaptive management actions, and a reduction in voluntary management actions for the species, such that many actions are no longer in place to mitigate future conditions including decreased water availability, future water development, or nonnative fish pressures.
    - LCR MSCP funding and adaptive management actions continue through 2055 as directed in the funding legislation. GCDAMP funding and management actions continue indefinitely.
    - Conservation actions codified under binding agreements (e.g. National Environmental Policy Act (NEPA), Section 7) would continue. For example, instream flows would be legally protected as they are today (e.g. Record of Decisions (ROD) and PBOs remain in effect); volunteer water management actions would likely cease.
    - State wildlife management actions would continue at self-directed levels. Mechanical control of nonnatives would likely cease or be severely reduced; monitoring would diminish to population monitoring that occurs at the state level only.

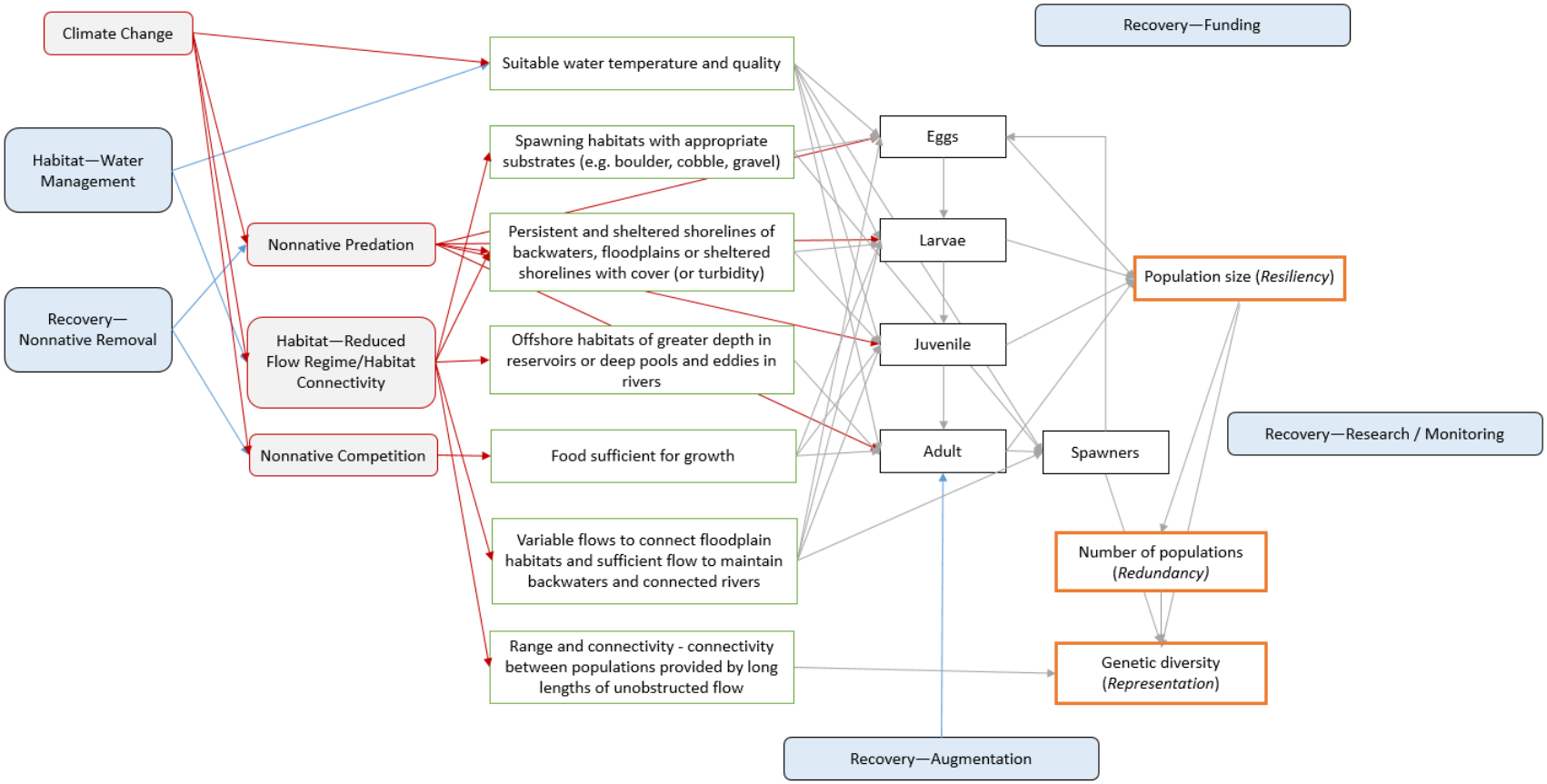


Figure 31. Flowchart of risks (gray with red outline) and management actions (blue rectangle) on razorback sucker individual and population needs (green outline) and their subsequent effects on the life stages (black outline) and 3Rs (orange outline), limited to tier 1 and 2 effects and those most likely to increase influence in future years. No lines are present connecting recovery program funding and research/monitoring to specific life stages as they have overarching effects on the entire system.

  - Screens & fish passages would likely not be maintained, wetlands & backwaters would not be managed or maintained for recruitment, and augmentation would dramatically diminish in the upper basin, but would continue in accordance with LCR MSCP guidance.

- Scenario 2 – Recovery actions continue at levels thought to be beneficial to the species as are currently in place, but augmentation efforts are less effective than is currently observed, resulting in a reduction in survival of stocked fish. Overall effectiveness of recovery actions is below current levels.
  - In addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies management practices occur into the future for the species.
  - Current and likely future actions include: mechanical removal of nonnative fishes in the upper basin, monitoring and research across populations, mandated and voluntary flow efforts to provide habitat and allow connection to nursery habitats actively managed by the programs in the upper basin, development and maintenance of predator free backwaters in the lower basin, maintenance of irrigation canal screens and fish passages, managing nonnative vegetation to restore habitat and active augmentation (i.e. stocking or reintroduction).
  - A decrease in effectiveness could be caused by a disease or parasite in the hatchery system or the establishment of a new predator in the system, reducing the survival of stocked fish (e.g. flathead catfish in the upper basin, or lack of concern about northern pike and smallmouth bass during the early years of the program).
  - Some participants assumed a negative management feedback loop would begin (e.g. if populations started to die off and were unable to be restored through augmentation that other efforts, other actions specifically related to habitat management may decrease as a result).

- Scenario 3 – Recovery actions continue at levels thought to be beneficial to the species (includes legally mandated actions plus adaptive and voluntary efforts currently in place), and are effective at reducing some threats. This scenario represents continuation of the status quo, both in terms of the current assemblage of recovery activities and their current levels of effectiveness.
  - In addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies management practices occur into the future for the species.
  - Current and likely future actions include all listed in Scenario 2

- Scenario 4 – Recovery actions continue at levels thought to be beneficial to the species (includes legally mandated actions plus adaptive and voluntary efforts currently in place) and are effective at reducing threats to a level supporting recruitment, which offsets some adult mortality. This scenario assumes reduction of current stressor(s) affecting populations.
  - In addition to minimum actions required under Scenario 1, additional proactive and adaptive management practices occur into the future for the species.
  - Current and likely future actions include all listed under Scenario 2.

  - Assumes a reduction in the pressure from nonnative predation, competition and/or habitat effects through either nonnative removal or establishment of predator free habitat. Management thought to repeat/increase floodplain habitat, successfully exclude predators from habitat or potentially remove large barriers to connectivity such as the San Juan Waterfall is incorporated.
  - Stocking assumed to decline and then possibly ceases because of wild populations in some places.

- Scenario 5 – Recovery actions support wild populations (includes legally mandated actions plus adaptive and voluntary efforts currently in place), and are effective at reducing most threats in the system. This scenario assumes the addition of more effective techniques to suppress effects of nonnative fishes, resulting in increased numbers of fish and enhancement of rearing habitats and their management such that recruitment completely sustains the viable populations without the need for augmentation.
  - In addition to minimum actions required under Scenario 1, additional proactive and adaptive stakeholder agencies management practices occur into the future for the species as needed.
  - Current and likely actions include all listed under Scenario 2 with the addition of new tools currently unavailable.
  - Assumes elimination of the pressure from nonnative predation, competition and/or habitat effects through novel techniques (e.g. genetic or biological) dramatically reducing nonnative populations in razorback sucker habitat.
  - Stocking assumed to decline and then possibly ceases because of wild populations in some places.
  - Mechanical removal of nonnative species ceases as other techniques are more successful.

The Science Team for scenario development were then asked to individually assess the effects of each of the scenarios on each of the species' habitat and demographic needs as explored in Chapter 3 and their assessment of current condition in Chapter 5. Each participant was asked if the current condition was likely to remain the same, increase by one condition category, increase by two or more condition categories, decrease by one category or decrease by two or more condition categories based on the condition category tables presented in Chapter 5 over the 30-year period. The results were averaged for each condition in each population and then averaged overall to provide a single resiliency prediction for each population. During the discussion about condition categories, the group noted that the condition category tables did not necessarily represent the entire range of environmental conditions from pre-anthropogenic effects to completely lacking ecological function, but instead represented a likely range of conditions. Therefore, during the future condition discussions, the results were allowed to incorporate values higher or lower than the categories in the condition category tables. The results of that assessment were compiled and presented here.

6.2.1 Scenario 1

Scenario 1 represents a dramatic decrease in conservation actions represented by the elimination of activities and programs not mandated by law. The upper basin programs (i.e. UCREFRP and

SJRIP) are currently operating under cooperative agreements through 2023 and are funded through 2019. Program partners are negotiating the extension of funding and work managed by the programs, but a future without the UCRB programs must be considered as a possibility.

The greatest threats from Scenario 1 in the upper basin would stem from increasing temperatures and lower flows with no flow management, coupled with unchecked nonnative predation and competition, and discontinuing stocking. Little would likely change in the lower basin as most actions are conservation-oriented (i.e. recovery is not the goal) and mandated through the LCR MSCP (Figure 32). As a Habitat Conservation Plan (HCP), the LCR MSCP program provides ESA compliance to any and all Federal and non-Federal actions, including flow and hydropower facilities, occurring in the study area over a 50-year time frame. A ROD published in 2005 authorizes implementation of the HCP through 2055. The (U.S. Department of Interior 2005). GCDAMP authorizations continue indefinitely.

Green River Subbasin - The Green River subbasin is home to the largest known population of razorback sucker in the Colorado River Basin. Although the more than 30,000 razorback sucker estimated to inhabit the basin are primarily hatchery fish, they actively spawn and produce larvae at several historic, and new, spawning bars on an annual basis. Recent flow recommendations out of Flaming Gorge have allowed for the development of managed wetlands that have produced young-of-year razorback sucker annually (operating under the biologically-based LTSP. Nonnative fishes have established resident populations that prey upon and compete with native fish. The primary threat comes from smallmouth bass, northern pike and walleye.

Stream flow would decrease and return to less natural flow regimes without active management because flows are heavily impacted by upstream reservoir operations. Operation of Flaming Gorge would continue under the 2006 ROD preventing catastrophic low flows, but flows on major tributaries like the White, Yampa and Duchesne would likely be in jeopardy. Increases in water demand or decreases in water supply could limit options available for the operation of Flaming Gorge Dam to primarily drier hydrologic conditions (i.e. reduce the number of years in which floodplain connections could be made), which would improve conditions for smallmouth bass in razorback sucker habitats.

The risk from predation/competition by nonnative fishes would increase substantially as smallmouth bass would be advantaged by lower flow conditions and subsequent warming of water, and would not be actively managed through nonnative removal programs. Habitat conditions are likely to decrease primarily because of less flow management and lack of floodplain access. Adults currently in the system would likely survive for a number of years, but would not be replaced by new individuals after stocking ceased, causing dramatic population declines, and reach extirpated condition over 30 years.

Colorado River Subbasin - The Colorado River subbasin population currently consists of about 8,000 adult razorback sucker. Although small numbers of fish are caught untagged, the vast majority of fish in the population are hatchery produced and recruitment is assumed rare. Nonnative fish populations are present throughout the system, with resident populations of smallmouth bass in both the main channel and tributaries.

Reduced stream flows caused by reduced snowpack would not be actively managed and would result in low water conditions, especially in late summer. Reclamation's ROD at the Aspinall Unit and other long-term flow commitments protect against extreme low flows, but voluntary flow management in the upper Colorado River could diminish, especially in the '15 mile reach' where spawning is prevalent. River temperature is expected to warm, but the direct effects on razorback sucker is not expected to be measureable. The food supply is reliable and is expected to continue to be suitable into the future, but may be impacted by drying conditions.

The risk from predation/competition by nonnative fishes would increase substantially as smallmouth bass would be advantaged by lower flow conditions and subsequent warming of water, and would not be actively managed through nonnative removal programs. The risk for increase and expansion of nonnative fishes is greatest in consecutive years of low flow, which would occur more often without management. Under this scenario, the Colorado River subbasin razorback sucker population would likely reach extirpated condition within 30 years.

San Juan Subbasin - The San Juan subbasin has a resident razorback sucker population of about 3,000 adults, developed through stocking efforts. Nonnative predation is not as prevalent as in the Colorado or Green river subbasins, with only channel catfish posing a threat. Razorback sucker recruitment remains poor to non-existent in the system. Researchers are exploring possible causes of recruitment failure.

Navajo Dam is the major water storage project in the basin and is required to release flows in accordance with the Biological Opinion (BO) for that system as long as water is present. If future climate predictions are accurate, this may be one of the areas hardest hit by reduced snowpack and drier conditions, severely limiting water availability in the basin. If the SJRIP were to cease management actions, the razorback sucker population would likely decline quickly and reach extirpated condition within 30 years.

Lake Powell - The status of the Lake Powell razorback sucker population is still very much in question as few studies have been completed to assess the population, and the studies that have been completed are usually focused on specific areas around the lake and not the lake in its entirety. There is a razorback sucker population resident to Lake Powell that consists of fish stocked in the Green, Colorado and San Juan subbasins as well as a substantial number of fish of unknown origin.

Lake Powell is not currently managed for razorback sucker, so the absence of management actions are not likely to have any effect on the habitat, however, reduced or eliminated stockings may reduce this population significantly. Increasing temperatures and decreased water availability could decrease lake levels, opening different habitat for razorback sucker. It is difficult to ascertain whether this would have a positive or negative benefit on the species. Although stocking does not occur in Lake Powell proper, many of the fish in this population originated through stocking in the upper basins, which indicates that a lack of stocking in those areas may lead to decreased population levels in the lake, causing extirpated conditions in 30 years.

Lake Mead (including Grand Canyon) – Lake Mead currently contains the only razorback sucker population in the system that is recruiting. Although population levels are low (around 500 individuals), razorback sucker are not augmented in Lake Mead and are not supported by management actions other than monitoring. Razorback sucker exist and recruit despite a heavy nonnative fish presence in the lake. There are no foreseeable plans to manage nonnative species by removal efforts. Therefore, the razorback sucker population in Lake Mead is likely to remain in a condition similar to current condition under Scenario 1.

Lake Mohave – The razorback sucker population in Lake Mohave has remained steady between 3,000-4,000 individuals over the last several years. The population in Lake Mohave serves as a genetic refuge for the species as they are the most diverse in the system. Razorback sucker recruitment is not occurring in the wild in Lake Mohave because of a dominance of large-bodied nonnative predators; populations are sustained by larvae collected during spawning season, reared in hatcheries and then re-released into the system as adults. The development of a naturally recruited and sustained population is improbable. This population is dependent on management actions mandated by the LCR MSCP and likely to remain so in the future; however, concern was expressed that an inability to implement adaptive management actions or add additional resources to habitat management would cause the population to be unable to cope with future changes. There are no foreseeable plans to manage nonnative species by removal efforts. This resulted in slightly lowered expectations for the Lake Mohave razorback sucker population into the future with demographic conditions remaining in a low category.

Colorado River between Davis and Parker dams (Lake Havasu) - Razorback sucker can now be found from the inflow area of Lake Havasu up-river to the base of Davis Dam, representing one of the more positive reintroduction efforts within the LCRB. The Lake Havasu population of razorback sucker now numbers between 3,000 and 5,000 individuals and was created by stocking efforts after naturally-occurring razorback sucker were extirpated from the area. Much like Lake Mohave, Lake Havasu is dominated by large-bodied nonnative predators and razorback sucker populations are sustained through stocking. The development of a naturally recruited and sustained razorback sucker population is improbable. This population is dependent on management actions mandated by the LCR MSCP and likely to remain so in the future; however, concern was expressed that an inability to implement adaptive management behaviors or add additional resources to habitat management would cause the population to be unable to cope with future environmental changes. There are no foreseeable plans to manage nonnative species by removal efforts. This resulted in slightly lowered expectations for Lake Havasu razorback sucker population into the future with conditions predicted to remain low over 30 years.

Colorado River downstream of Parker Dam – The razorback sucker population in the reach downstream of Parker Dam is also heavily managed by LCR MSCP, but has not seen the same success as upstream populations. Despite continued stocking efforts, razorback sucker populations have not established in the mainstem Colorado, but do persist in a few off channel locations. The habitat in this section is complex and adequate for establishment of a razorback sucker population, but predation from both large-bodied nonnative fishes and avian predators remains high. There are no foreseeable plans to manage nonnative species by removal efforts. The LCR MSCP is trying to reestablish resident populations of razorback sucker in this area;

should adaptive management measures be eliminated, the population level is likely to fall below its already extirpated condition within 30 years.

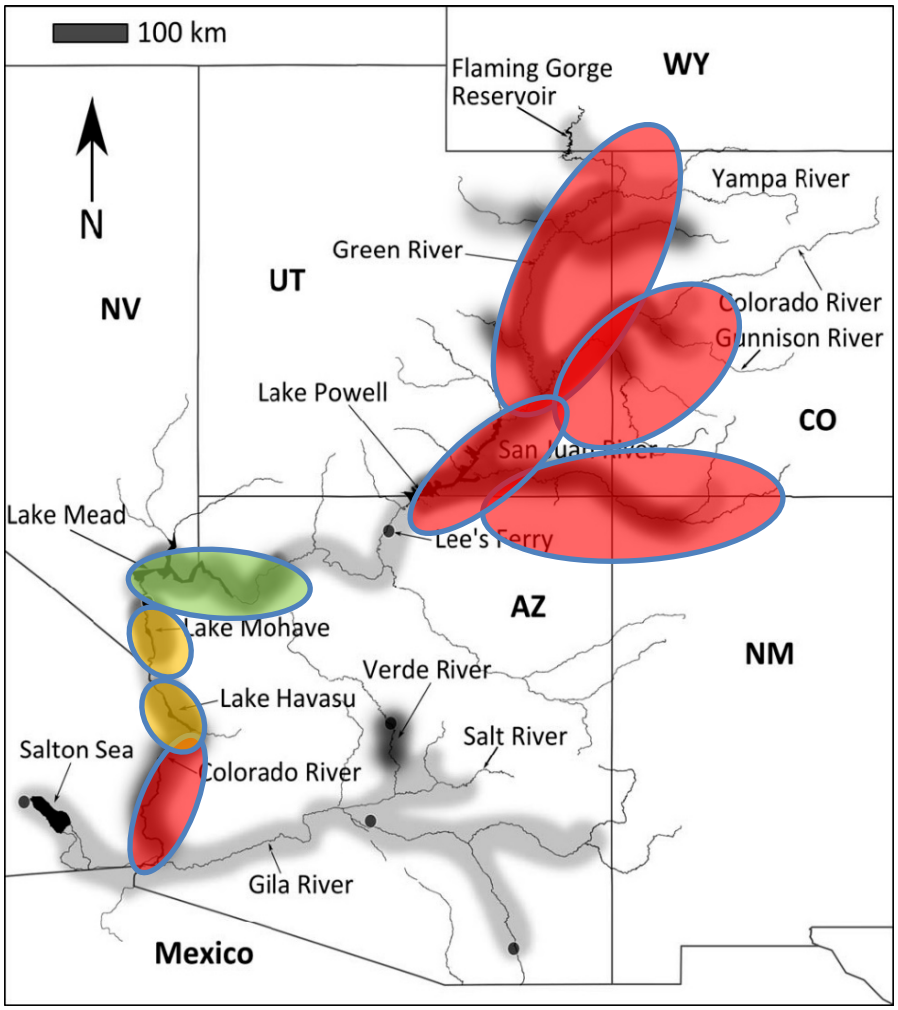


Figure 32. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing predicted response in demographic species needs under Scenario 1. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

6.2.2 Scenario 2

Scenario 2 represents continued conservation actions for razorback sucker above and beyond those mandated by law and consistent with current efforts, but assumes stocking success declines as a management tool (Figure 33). The continued conservation actions include all program actions currently occurring in both the upper and lower basin, including nonnative fish management, screen and passage maintenance, augmentation, habitat development and flow management. The novel threat was interpreted in two ways, either that the threat was limited to a hatchery system, thereby making augmentation unsuccessful but not impacting populations already in the system (e.g. hatchery-based disease), or a threat was to fish currently in the system

in addition to those stocked (e.g. novel predator). Both interpretations assume a reduction in the survival of stocked razorback sucker, not a complete arrest of stocking success.

Green River Subbasin – In this scenario, habitat conditions are likely to decline, but not severely, primarily because of the introduction of a novel predator or competitor in the system which would make rearing habitat less available or conducive to survival. Razorback sucker demographic conditions under this scenario would likely decline, but more slowly than under Scenario 1. The razorback sucker population is currently large, which may indicate a long slow decline is likely in the absence of effective stocking. Active management of floodplain wetlands may support the wild recruitment of at least some juveniles even if hatchery stock were not available. Continued management of flow, nonnative populations, canal screens and fish passages would slow the decline of razorback sucker currently stocked in the system. Under this scenario, the Green River subbasin population would likely decline to a low condition in 30 years, but may not be extirpated.

Colorado River Subbasin – In this scenario, habitat conditions for razorback sucker are likely to decline, but not severely, primarily because of the introduction of a novel predator or competitor in the system, which would make habitat less available or conducive to survival. Razorback sucker demographic conditions under this scenario would likely decline, but more slowly than under Scenario 1. Continued management of flow, nonnative populations, canal screens and fish passages would slow the elimination of razorback sucker currently stocked in the system. Under this scenario, the Colorado River subbasin population would likely decline to a low condition in 30 years and may be approaching extirpation.

San Juan River Subbasin – The San Juan River razorback sucker population is currently the smallest of the upper basin riverine populations and is reliant on stocking. Under Scenario 2, the San Juan River subbasin population would see a more dramatic decline in demographic condition than in the Green or Colorado subbasins. The population in the San Juan River shows signs of bottlenecks at multiple stages of development, including the larval stage. Although off-channel and backwater habitat is actively being developed, the system has a paucity of nursery habitats available to the razorback sucker. Fish passage is currently blocked by the waterfall; the blockage is expected to persist as lake levels drop. The predatory nonnative fishes are limited to channel catfish, which can compete with razorback sucker for niche space and become piscivorous at large sizes. Although declines in the razorback sucker population in this basin are predicted to be substantial in this scenario, they are predicted to be less dramatic than in Scenario 1, indicating that management actions in addition to stocking are important.

Lake Powell – The Lake Powell razorback sucker population is also expected to decline under Scenario 2, but at rates slower than the other upper basin populations. Other than population monitoring, management actions are currently not occurring in Lake Powell. An anticipated decline in Razorback Sucker population is based on a lack of hatchery fish migrating from other upper basin populations into the Lake Powell system. Without augmentation, the razorback sucker population levels are likely to decline.

Lake Mead – As noted above, very few management actions are occurring in Lake Mead to support the only successfully recruiting razorback sucker population in either basin. The

Razorback Sucker population in Lake Mead has not been augmented by hatchery stock, although a few research fish have been released to help determine the location of other fish in the population. Razorback sucker persist and recruit at a low level, despite a heavy nonnative fish presence in the lake. There are no foreseeable plans to manage nonnative species by removal efforts. Therefore, the Razorback Sucker population in Lake Mead is likely to remain in a condition similar to current condition under Scenario 2.

Lake Mohave – The razorback sucker population in Lake Mohave is heavily dependent on the management action of capturing larvae during spawning season, growing the fish in off-channel or hatchery ponds and returning them to Lake Mohave as adults large enough to survive in a lake dominated by nonnative predators. If this management tool were to decrease in effectiveness, it would have a substantial effect on the razorback sucker populations from a demographic standpoint. Many participants predicted declines in both the adult population and the resulting spawn and larval presence, indicating that a negative feedback loop would make maintaining this genetically robust population very difficult. It is important to note that in a system dominated by nonnative predators, it is unlikely that a novel predator could increase predation significantly above current levels; therefore, the threat was more likely considered a disease or other factor causing declines in survival after stocking. There are no foreseeable plans to manage nonnative species by removal efforts.

Colorado River between Davis and Parker dams (Lake Havasu) – The razorback sucker population downstream of Davis Dam is likely to follow a similar pattern to that of Lake Mohave. Should stocking success decline, the Razorback Sucker population would likely decline as well. There are no foreseeable plans to manage nonnative species by removal efforts in this area.

Colorado River below Parker Dam – The area downstream of Parker Dam is currently stocked with razorback sucker, yet survival remains low. The habitat present below Parker Dam is thought sufficient, but predation is high from both birds and nonnative fish. There are no foreseeable plans to manage nonnative species by removal efforts. A decline in the effectiveness of razorback sucker stocking would likely extirpate this population in the 30 years considered as future, if not before.

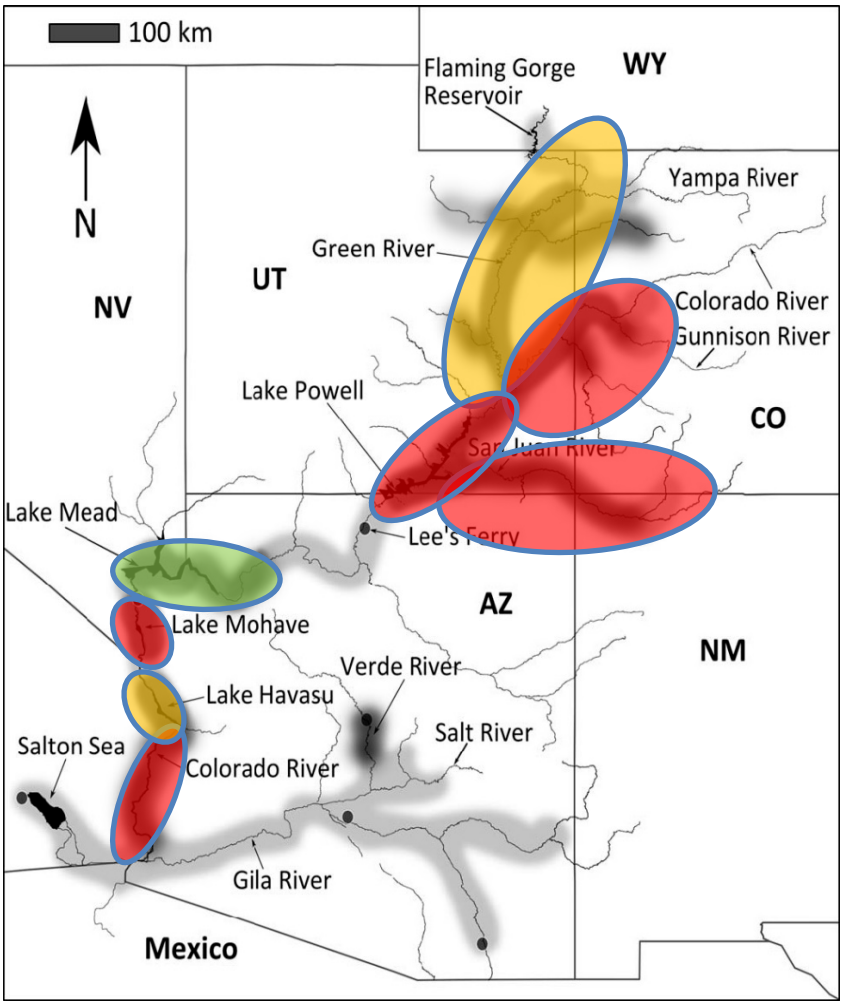


Figure 33. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing predicted response in demographic species needs under Scenario 2. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

6.2.3 Scenario 3

Scenario 3 represents a continuation of all management actions currently occurring under the UCREFRP, SJRIP, GCDAMP and LCR MSCP. These actions include flow and habitat management, nonnative fish removal, maintenance of screens and passages, research and monitoring to varying degrees across the populations. In all razorback sucker populations, slight increases in condition are anticipated with continuation of current management actions (continuing a trend developed over the last thirty years of management actions). Over the past 30 years, the programs have effectively developed stocking programs, managed flows to mimic natural flows to the extent possible and respond to biological triggers, removed barriers to migration, added canal screens to prevent entrainment, and created or improved habitat specifically managed for razorback sucker. The Programs have repeatedly identified and

eliminated threats through their adaptive nature and that trend is expected to continue. When compared to the improvements over the last thirty years, the improvement rate is expected to decline, as some of the largest threats (e.g. nonnative predators) are persistent and difficult to eliminate. The improvements are anticipated to be larger in the upper basin in comparison to the lower basin (Figure 34). Changes in the Green and Colorado river subbasins are driven by demographic improvements as much of the physical habitat improvements thought to be necessary for population success have been accomplished. A number of habitat improvements or barrier elimination projects in the San Juan are still underway.

The Lake Mead razorback sucker population is expected to improve less because of the lack of current management actions associated with that population. Should the adaptive programs in the lower basin choose to add management actions, the gains would likely increase. There are no foreseeable plans to manage nonnative species by removal efforts in any lower basin population so the increases in condition are expected to be driven primarily by increasing off-channel and backwater habitat to the extent feasible.

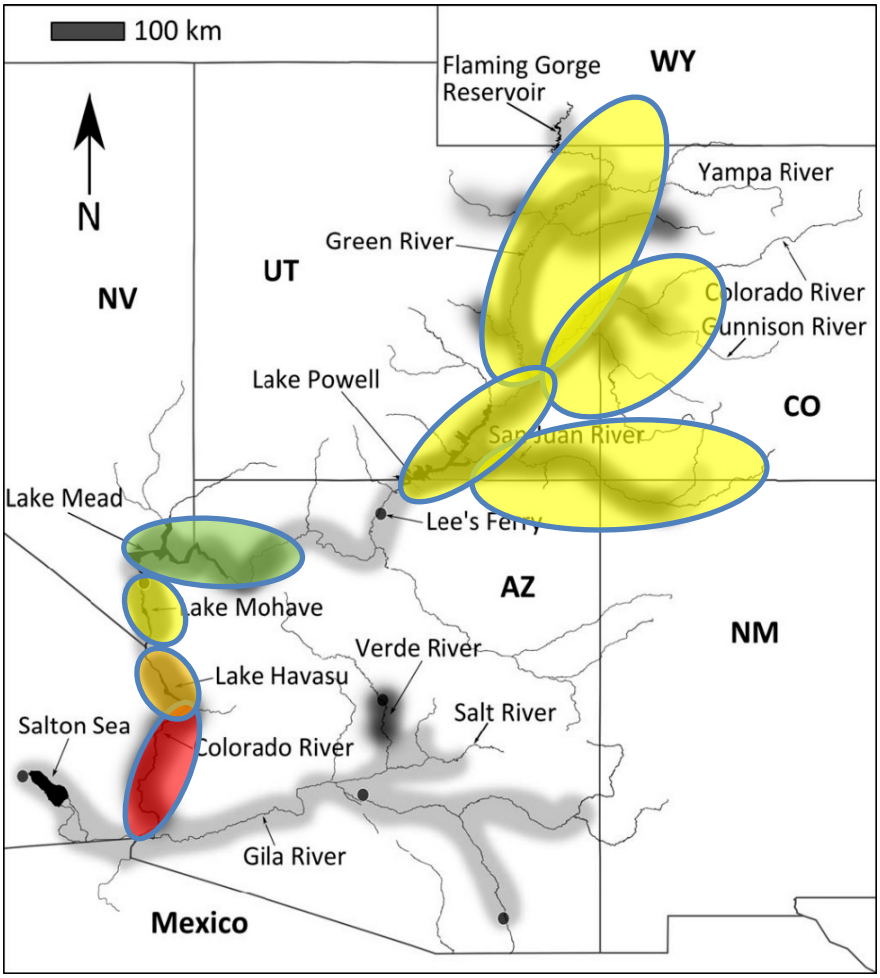


Figure 34. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing predicted response in demographic species needs under Scenario 3. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

6.2.4 Scenario 4

Scenario 4 represents the continuation of all razorback sucker management actions occurring in Scenario 3, but anticipates an increase in effectiveness of those actions, specifically that support recruitment (Figure 35). The actions include flow and habitat management, nonnative fish removal, research and monitoring to varying degrees across the populations. Scenario 4 anticipates dramatic improvement in some aspect of management. For example, this could include increasing fish passage structures to increase connections (e.g. over the San Juan Waterfall), increases in the number or distribution of floodplain wetland habitats (in the UCRB) or off-channel backwater habitat (in the LCRB) allowing substantial razorback sucker recruitment to occur to the juvenile life stage, or dramatic decreases in the resident populations of nonnative fishes due to increased effectiveness of nonnative removal. Increased effectiveness of nonnative removal in the upper basin could occur from spike flows, which could decrease smallmouth bass populations on a river-wide scale by decreasing parental protection of larvae. Spike flows are an experimental technique where flows and/or turbidity are increased just after bass larvae hatch, which moves adults off the nest and subjects the larvae to predation (Bestgen *et al.* 2018). Preliminary results from a conveniently timed rainstorm in 2015 show an opportunity for river-wide reductions in year-class development of smallmouth bass. As in Scenario 3, the effects of these changes are likely larger in upper basin populations and lowest in Lake Mead where management actions are limited. There are no foreseeable plans to manage nonnative species by removal efforts in the lower basin. Projected increases in the lower basin assume development of sufficient backwater or off-channel habitat to allow recruitment to occur.

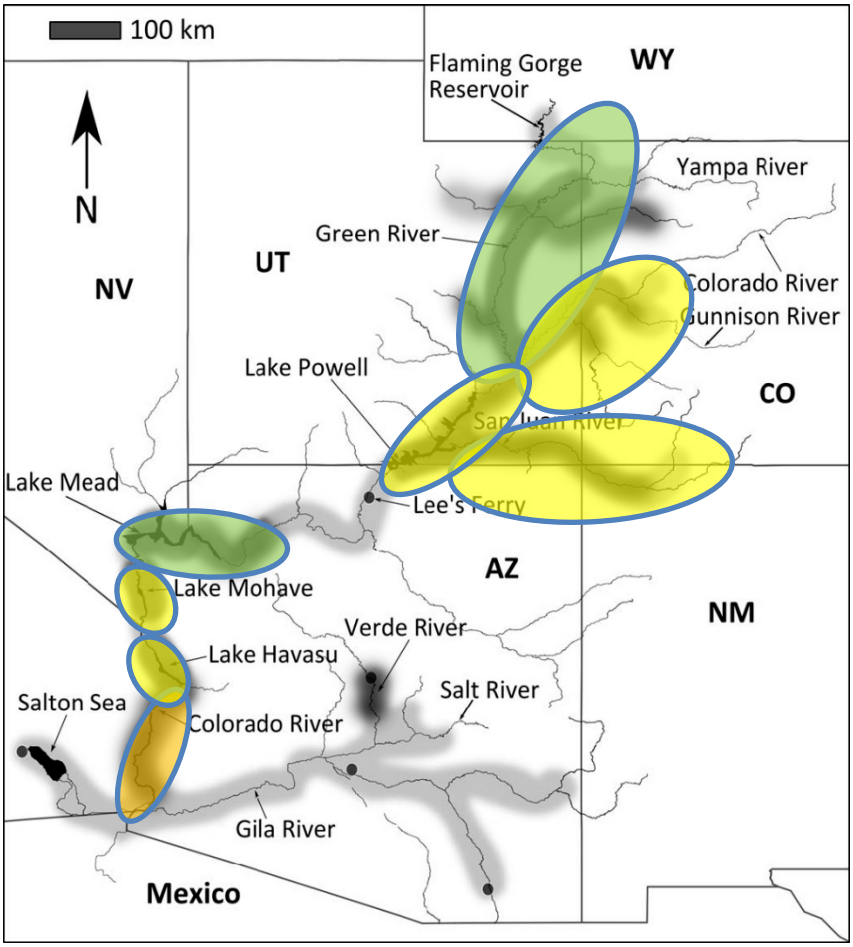


Figure 35. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing predicted response in demographic species needs under Scenario 4. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

6.2.5 Scenario 5

Scenario 5 represents a dramatic shift in our ability to manage the ecosystem, primarily in the realm of nonnative fish control or habitat. As in Scenarios 3 and 4, all management actions and commitments for Razorback Sucker continue, but in this case, the increase in effectiveness is dramatic (Figure 36). Participants believed the development of this scenario was unlikely, but wanted to acknowledge that many strides have been made in humankind's ability to manage invasive plant species and that such an increase may also occur in aquatic systems during the next 30 years, potentially through genetic means.

If nonnative fishes were able to be removed from the system on a large scale or if habitat modifications could be more effective at providing shelter for key life stages, the effects on razorback sucker would likely be dramatic. The cumulative effects of nonnative fishes ranging from small nonnative cyprinids to large predators is likely limiting the return of populations to

their previous sizes. Should tool(s) be available to clear the system of invasive effects or provide suitable habitat in a novel way, the result would likely be dramatic increases in razorback sucker demographic criteria. Upper basin populations would likely return to high condition, while lower basin populations may return to a moderate condition. The effects in lower basin populations are thought to be smaller because of the continued desire for nonnative sportfish in the major reservoirs of the Southwest. If elimination of nonnative fishes were possible, it may be politically untenable for some species.

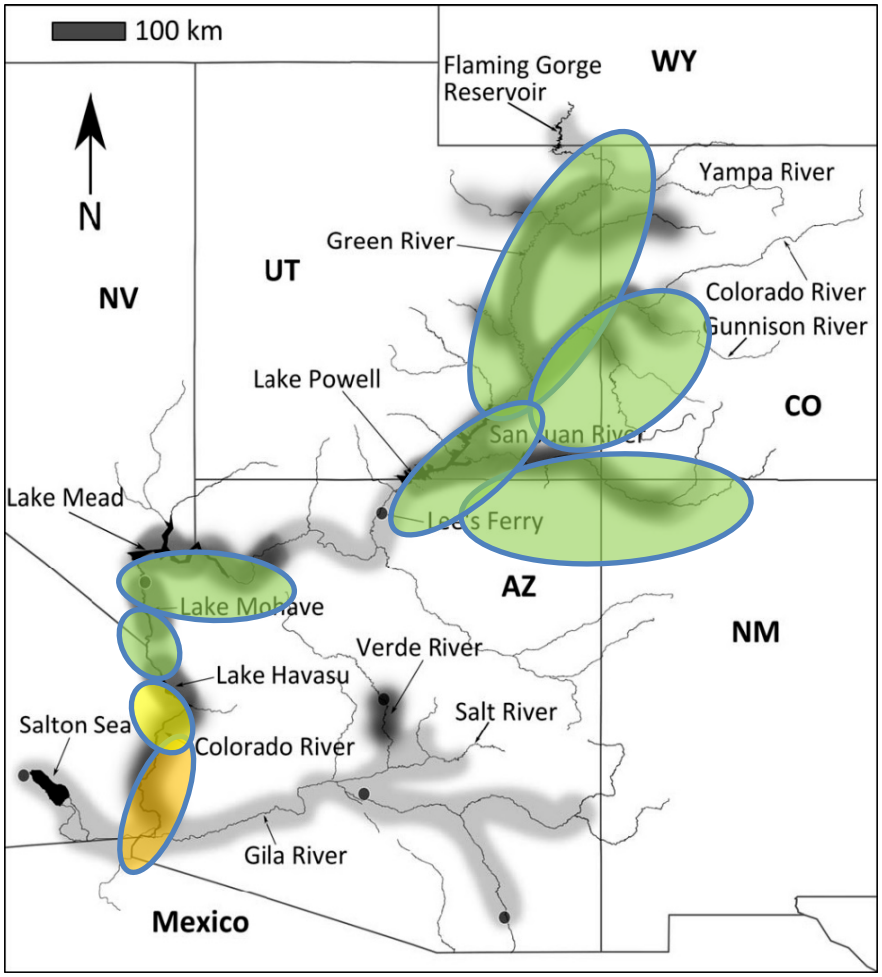


Figure 36. Historical (light gray) and current (dark gray) distribution of the razorback sucker in the Colorado River with different populations indicated by ellipses with colors representing predicted response in demographic species needs under Scenario 5. High condition is indicated by green (average score of 2.26-3), medium condition is indicated by yellow (1.51-2.25), low condition is indicated by orange (0.76-1.5), and extirpated condition is indicated by red (0-0.75).

6.2.6 Future Viability

6.2.6.1 Upper Basin

The results of the management based future scenarios predict a range of future conditions ranging from restoration of most populations to a high condition to returning to the low condition seen in the last century (Figure 37). Multiple management actions have been taken to date to improve razorback sucker populations from previous low levels. After populations in the upper basin crashed in the early 1990's, individual razorback sucker were brought into hatcheries to form a broodstock. After decades of stocking, some populations of stocked fish are growing as annual survival of stocked fish increases. Flow recommendations have been developed and implemented at multiple reservoir systems in the upper basin in an attempt to mimic the natural hydrograph to the extent possible. In the Green River, flow recommendations include biologically based triggers that increase flows after razorback sucker larvae are detected in the river, creating a connection to floodplain wetlands, allowing larval fish to enter managed wetland systems. Fish screens and fish passages have been constructed to prevent entrainment in canals and allow for migration of native species across the basin.

With these management actions, razorback sucker populations have shown dramatic improvements in redundancy. Razorback sucker can now be found across all upper Colorado River subbasins, in both mainstems and tributaries. Genetic integrity has been managed through the stocking process and genetic diversity has remained consistent with the diversity found when the populations were first studied. Resiliency of the populations remains low because of the lack of recruitment in the populations. Scenarios 3, 4 and 5 include predicted improvements in resiliency of the populations based on continued management actions. Scenarios 1 and 2 represent declines in redundancy and resiliency of the upper basin population as management actions would reduce in scope or effectiveness.

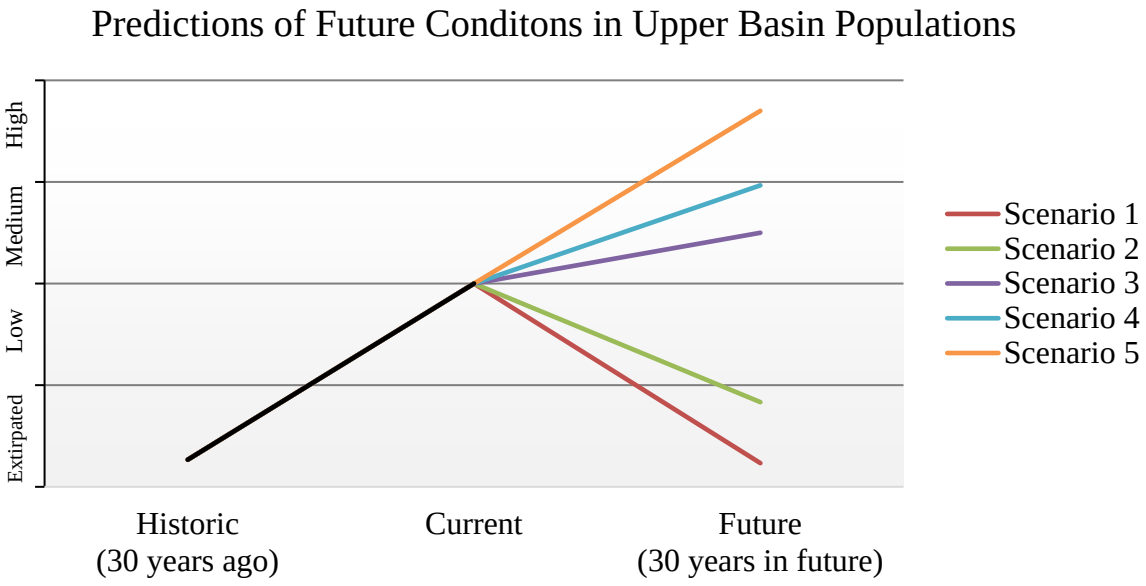


Figure 37. Prediction of razorback sucker population responses under the five future scenarios for all upper basin populations.

6.2.6.2 Lower Basin

The results of the management based future scenarios predict a much narrower range of future conditions for Razorback Sucker populations in the lower basin than in the upper basin mostly because of the dominance of nonnative predators in the lower basin that are managed and valued as sportfish (Figure 37). Razorback sucker populations are currently managed across the basin, and efforts attempts develop new populations across historic habitat via stocking continue. The resident populations of striped bass and flathead catfish in the large reservoirs within the lower Colorado River basin are likely to continue to suppress or eliminate razorback sucker recruitment. While some off-channel habitats may continue to be developed and lead to improved populations, it is unlikely that populations in the lower basin will ever be considered high condition. With the possible exception of Lake Mead, lower basin populations are not resilient in the face of nonnative predation and are unlikely to become so. Genetic integrity is intact and more robust than in the upper basin populations, but only through a heavily managed re-introduction program. Redundant populations of Razorback Suckers are currently in place but not successful in all populations, but would be at risk without continued management.

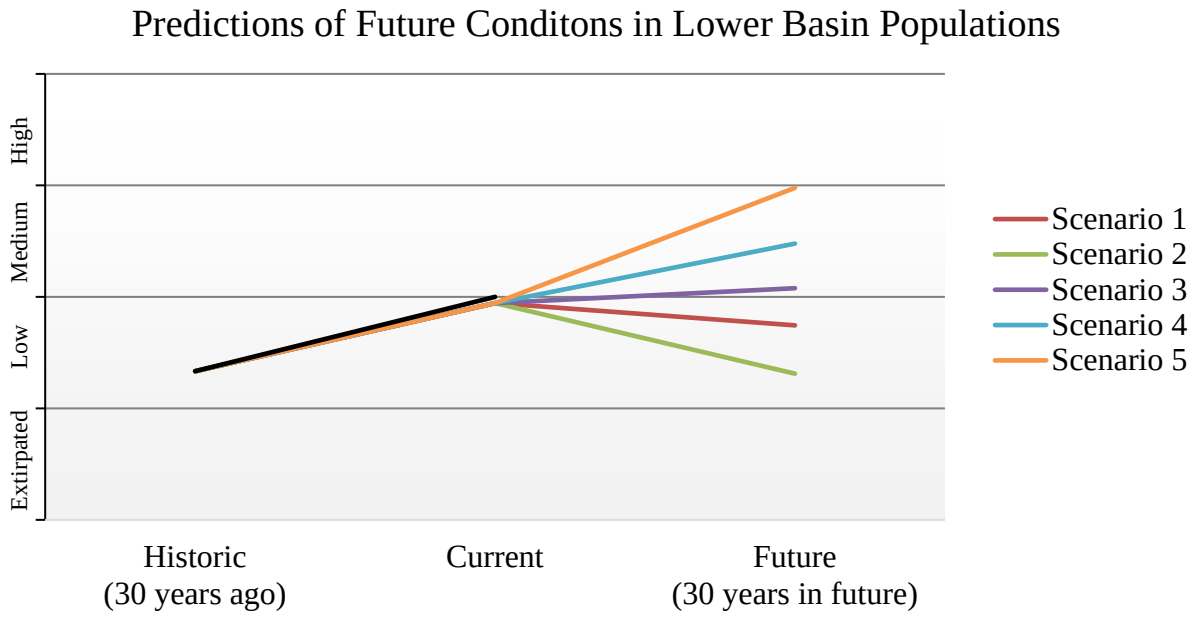


Figure 38. Prediction of razorback sucker population responses under the five future scenarios for all Colorado River lower basin populations.

6.2.6.3 Summary

When razorback sucker populations across both basins are considered together, predicted future condition ranges from high to low, with a larger distribution of values in the upper basin driving the range (Figure 39). The current condition of razorback sucker has been driven by conservation actions that have occurred over the last 30 years, and it is likely that the population condition in the future will also be driven by those management actions. If management actions continue at

current or increasing levels of success, improvements are expected in resiliency. Should management actions cease, resiliency, redundancy and representation of the species are likely to decline.

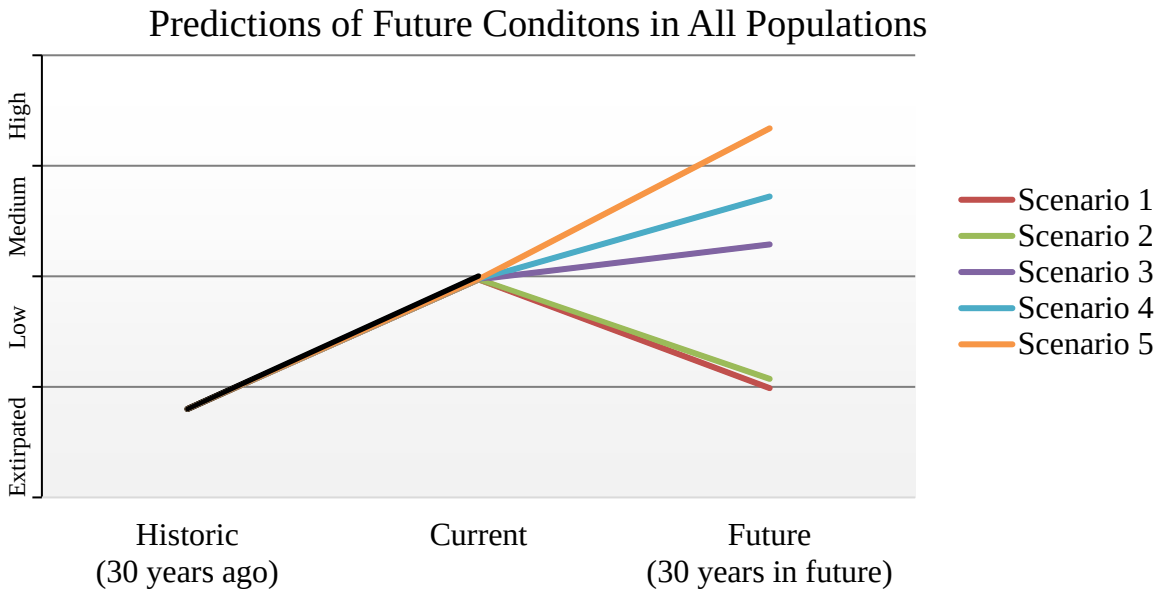


Figure 39. Prediction of razorback sucker population response under the five future scenarios for all Colorado River populations.

Based on this range of potential future condition, we asked the Science Team participants to predict likelihood of each scenario using the values presented in Table 16.

Table 16. Likelihood values used to assess future condition.

Term	Likelihood of the outcome
Virtually certain	99-100% probability
Extremely likely	95-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33-66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Extremely unlikely	0-5% probability

Both scenarios 4 and 5 were judged unlikely at both the 30-year and 100-year time frame, with the possibility of population scale effects being very unlikely at 30 years (Table 17). Participants judged Scenario 3 to be the most likely scenario over the 30-year time frame, but indicated that over a longer time frame of 100 years, that both Scenario 2 and Scenario 3 were equally likely. Participants also noted that Scenario 1 was unlikely in the near term as some funding arrangements are more certain over that time frame than others (e.g. LCR MSCP and GCDAMP) or under current negotiation with strong partner support (e.g. UCREFRP and SJRIP). Scenario 1 became more likely in the long term based on the expiration date of those agreements.

Table 17. Likelihood of scenarios as predicted by the science group of occurring at 30 years and 100 years.

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
30 yrs	Unlikely	About as likely as not	Very likely	Unlikely	Very unlikely
100 yrs	About as likely as not	Likely	Likely	Unlikely	Unlikely

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8 APPENDIX A: DELPHI METHODS

For the current Delphi questionnaire, a multicriteria analysis (MCA) framework was devised to quantitatively distinguish expert opinions regarding the influence of factors on viability and to identify potential geographical differences in influence (e.g., UCRB and LCRB). There are various approaches to constructing a MCA. For the current process, the MCA was developed using a simple example of a weighted sum model (Natural Resources Leadership Institute 2016) and an example of using this type of model in an ecological Delphi process (Grech and Marsh 2008). In this model, a list of influencing factors are first ranked and weighted by each participating expert. Then each expert rates the same list of factors for geographic locations (i.e., the UCRB and LCRB). Ratings for each basin were multiplied by the weights assigned to the factors and then summed to create a composite index by basin. For purposes of the survey, and as described previously for this document, we defined the UCRB as all razorback sucker populations above Glen Canyon Dam and the LCRB as all populations below Glen Canyon Dam.

8.1 Participant Selection

Biologists working with razorback sucker in both the UCRB and LCRB were asked to provide a list of other biologists in their region who have worked with the species, including retired as well as recently hired biologists. Fifty-six of 87 invited biologists participated in the first-round questionnaire, and 47 biologists continued to participate in the second and third rounds. Biologists had a wide range of views, assumptions, perceptions and/or sources of information when completing these surveys.

8.2 First Round Scoring Survey

In the first Delphi round, participants were asked to rank and weight a list of factors and subfactors potentially influencing the near-term viability of razorback sucker (within the next 30 years).

Table 18. Major factors potentially influencing Razorback Sucker population viability as presented to participants in the first Delphi round (subfactors are indicated in parentheses) as they relate to the 2002 recovery goals recovery factor criteria.

Factors Potentially Influencing Viability of razorback sucker during the Next 30 Years, Listed Alphabetically	Recovery Goal Factor	Recovery Factor Criteria from 2002 recovery goals
Climate Change	A	Adequate habitat and range for recovered populations provided.
Conservation and Recovery Efforts (augmentation, non-native fish removal, program funding, research and monitoring)	D	Adequate existing regulatory mechanisms.
Genetic Factors (diversity, hybridization)	E	Other natural or manmade factors for which protection has been provided.
Habitat (flow regime/connectivity, land use, water management/habitat availability, water temperature)	A	Adequate habitat and range for recovered populations provided.

Non-native and Invasive Species (competition, habitat effects, predation)	C	Adequate protection from diseases and predation.
Overutilization (use of species for commercial, recreational, scientific, or educational purposes)	B	Protection from overutilization for commercial, recreation, scientific, or educational purposes.
Parasites and Diseases	C	Adequate protection from diseases and predation.
Pollutants (heavy metals, runoff, spills)	E	Other natural or manmade factors for which protection has been provided.

The first round questionnaire was administered as an internet survey that was pretested internally with a small group of fisheries biologists and USFWS project leads. Following the pretest, the categories of factors and definitions of factors were revised based on input received. Initially, water management factors were separate from habitat, but it was found that these were being weighted equally by the pretest group. Because it appeared that these factors would not be distinguishable, they were combined.

The ranking and weighting exercise involved three steps. For the first step, each participant ranked eight major categories of factors in perceived order of importance and assigned each factor a weight out of 100 total points. For the second step, participants weighted subfactors for five of the eight major categories. Each subfactor could be weighted up to or equal to the assigned major factor for that category. For example, if a participant assigned a weight of 10 to genetic factors (major category), then the participant could give both genetic diversity and hybridization (subfactors) any weight between 0 and 10. For the third step, participants rated each of the razorback sucker viability factors for the UCRB and LCRB using a 1–5 rating scale with 1 representing “not at all influential” and 5 indicating “very influential.”

The invitation to participate in the first round survey (Appendix A) included definitions of factors, subfactors, and viability, and information regarding internet survey access. Participants were also asked if they wanted to share general thoughts and observations about razorback sucker abundance, distribution, and diversity, which are essential characteristics that contribute to a species’ ability to sustain populations in the wild over time (D. R. Smith *et al.* 2018) .

8.3 Second Round Comment Survey

In the second round, each participant was sent a customized report indicating how their weightings compared with the group response. The report flagged any individual’s factor and subfactor weightings that were higher or lower than the group average by one standard deviation. Each participant was asked to comment on their higher and lower weightings, as well as to provide any other observations that they wanted to share. Participants were not asked to reweight factors in this round because they had not yet had the opportunity to review comments from other participants.

8.4 Third Round Scoring Survey

The third round survey was also a customized report showing how each participant’s factor and subfactor weights compared with the group’s; this time the weights were presented with the

second round comments from all participants. In this round, participants were asked to consider the comments and reweight each factor and subfactor (they could keep the existing weight or select a higher or lower weight based on their reaction to comments). Definitions of the factors and subfactors provided in the first round were repeated to help participants focus weighting on a common understanding of the factors and subfactors.

Because there is no standard type of data collection for a Delphi process (in this case, an MCA model was developed), there is also no standardized method of assessing change between rounds. In general, Delphi assessment is concerned with the degree to which participants agreed more with one another in subsequent rounds after consideration of comments. Measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation, standard error, range, interquartile range) can all be appropriate for this purpose (Holey *et al.* 2007; Hsu and Sandford 2007). The MCA model (factor weighting and ranking) lends itself to use of the mean, standard deviation, and standard error, as well as to statistical tests such as ANOVA; all of these statistics were utilized in evaluating the results of the razorback sucker SSA Delphi process.

8.5 Delphi Results

This section presents participant characteristics (years of experience and knowledge of the basins in which participants primarily worked), weighting modifications from Round 1 to Round 3, and outcomes of the weighting process in terms of the perceived influence of factors and subfactors on the viability of razorback sucker.

8.5.1 Participant Characteristics

Among the 47 participating biologists, experience working with razorback sucker ranged from 1 to 45 years, averaging 17 years and representing 815 collective years of experience (Figure 40). Of the 47 participants, 22 are biologists who primarily worked in the UCRB, 17 primarily worked in the LCRB, and 8 have experience working in both basins.

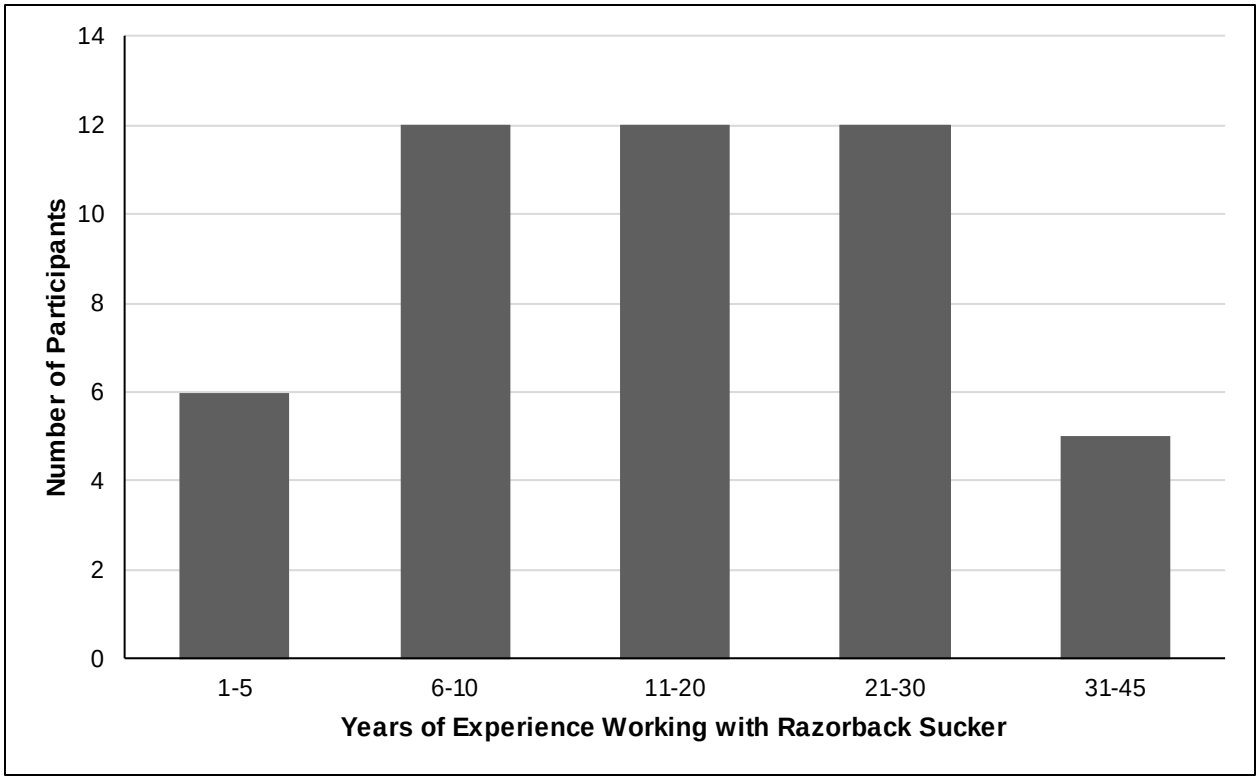


Figure 40. Participant years of experience working with razorback sucker recovery and monitoring.

8.5.2 Factor Scoring Changes from Round 1 to Round 3

On average, participants weighted nonnative predation as the most influential factor, followed closely by two habitat-influencing factors: flow regime and water management (Table 19 and Figure 41). Table 19 presents descriptive statistical comparisons for the distribution of individual responses from Rounds 1 and 3 (mean, median, standard deviation, minimum value, and maximum value), as well as the change in standard deviation and range between rounds. Statistics indicating variability in weightings (the interquartile range and the minimum and maximum weights) suggest that there were higher levels of agreement regarding the less influential factors. In particular, the interquartile range was less than 10 for genetic factors (genetic diversity and hybridization), pollutant factors (heavy metals, runoff pollution, contaminant spills), parasites and diseases, and overutilization, indicating that at least half of the participants weighted these factors within 10 points of one another.

Figure 41 presents a comparison of the means. The error bars in Figure 41 represent ± 2 standard errors from the mean (approximately the 95% confidence interval of the mean). Comparison of the error bars for each factor illustrate that there were no significant changes in mean weighting from Round 1 to Round 3, which was also confirmed by ANOVA tests (ANOVA, $p<0.05$ for all factors). There were no changes in the rank order of mean weights between scoring rounds. The most noticeable change was an increase in weights assigned to the five top-ranked factors, with nonnative predation receiving the largest increase in weight. However, variability in weights assigned to the most influential factors remained high in Round 3, as compared with the lower-weighted factors.

Table 19. Descriptive statistics comparing Round 1 weighting with Round 3 weighting.

Factor	Round 1						Round 3					
	Mean	Standard Deviation	Median	IQR[a]	Minimum	Maximum	Mean	Standard Deviation	Median	IQR[a]	Minimum	Maximum
Nonnative Predation	23.0	11.7	20	20	4	60	27.6	12.9	25	15	10	60
Habitat - Flow Regime	20.6	13.8	20	20	3	60	22.8	13.1	20	18	4	50
Habitat - Water Management	20.1	12.5	20	14	3	50	22.0	12.1	20	10	4	50
Recovery - Funding	15.2	12.7	10	10	0	60	17.7	12.6	15	8	2	60
Recovery - Augmentation	15.0	12.0	10	15	0	60	16.9	11.3	15	15	0	50
Recovery - Nonnative Removal	13.8	11.9	10	10	0	60	13.5	12.0	10	10	0	60
Recovery - Research/ Monitoring	12.8	11.0	10	14	0	60	12.5	8.3	10	10	1	50
Nonnative Competition	11.8	11.1	10	15	0	50	12.2	9.5	10	10	0	40
Nonnative/Invasive Habitat Effects	9.9	10.5	8	15	0	50	9.9	7.9	10	15	0	35
Habitat - Water Temperature	9.9	12.0	5	15	0	50	9.5	9.1	7	15	0	50
Climate Change	8.7	6.5	6	15	0	25	9.1	6.4	8	14	0	25
Habitat - Land Use	8.0	10.8	4	11	0	50	8.3	9.5	5	10	0	50
Genetic Diversity	5.9	5.2	4	8	0	20	5.9	4.9	5	8	0	20
Heavy Metals	3.8	3.1	3	4	0	10	3.7	2.7	3	4	0	10
Hybridization	3.3	3.1	2	3	0	12	2.9	2.8	2	3	0	10
Parasites and Diseases	3.1	2.4	3	1	0	10	2.6	1.9	2	1	0	8
Runoff Pollution	2.3	2.4	2	3	0	10	2.1	2.0	2	2	0	10
Contaminant Spills	2.1	2.6	1	4	0	10	2.2	2.3	2	3	0	10
Overutilization	1.6	2.0	1	3	0	5	1.4	1.9	1	2	0	5

[a] The interquartile range is the range of the middle 50 percent of responses, or the difference between the 75th percentile and the 25th percentile.

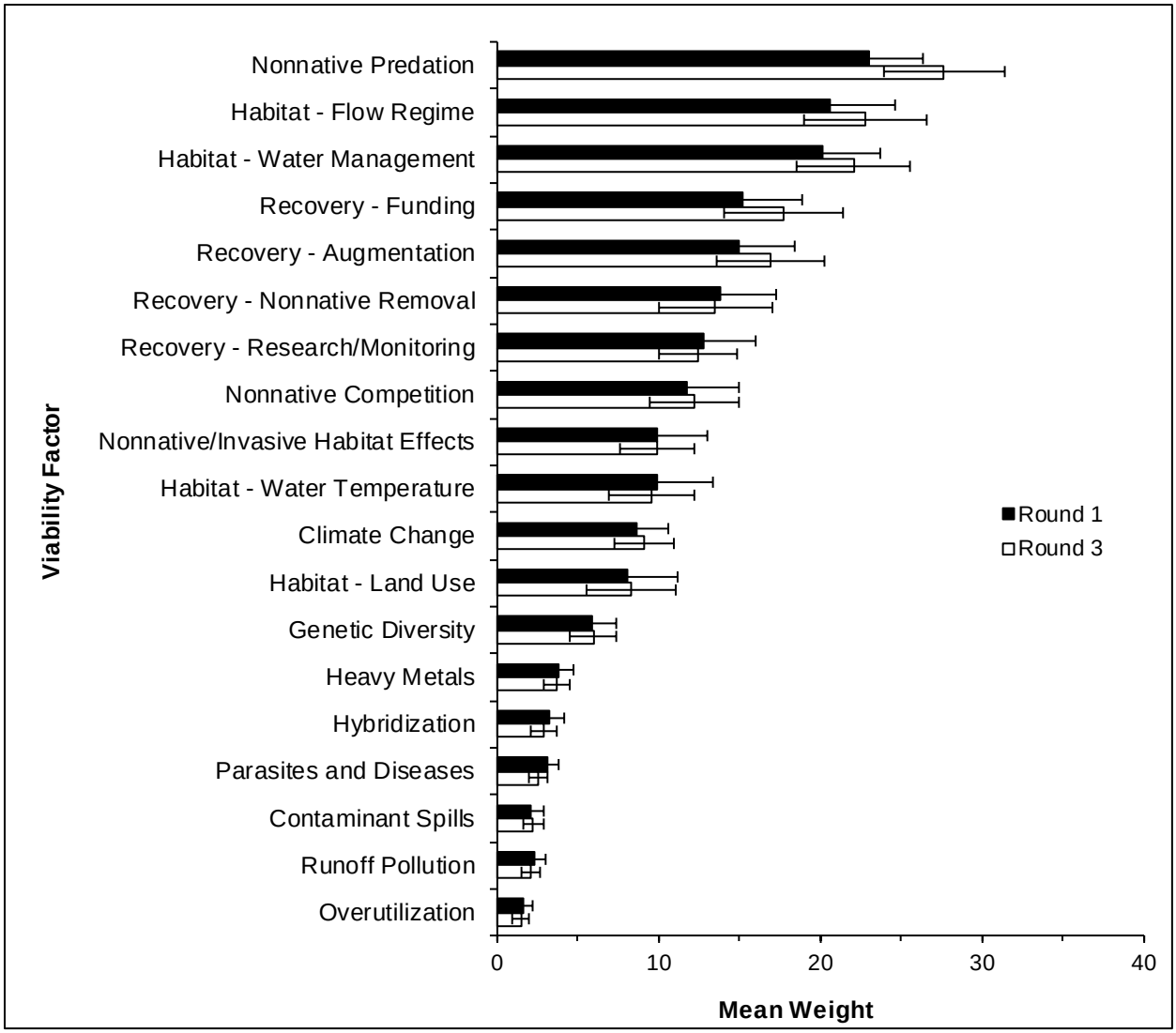


Figure 41. Mean weights assigned to factors potentially influencing viability of razorback sucker during the next 30 years (± 2 Standard Errors).

Overall, there was a reduction in variability of factor weights after Round 3 with the notable exception of nonnative predation which increased in variability, and the variance for nonnative removal also increased slightly (Figure 42). It is notable that all participants who changed the weight that they had assigned to nonnative predation in Round 3 increased their scores from Round 1; this was the only factor for which none of the participants decided to decrease their weight from Round 1. The increase in variability for nonnative predation was due to differences in the degree to which various participants chose to increase the weight. Thus, there was an overall increase in the group's perceived weight of influence for nonnative predation and, hence, increased agreement that this factor is an important influence on viability. However, because the range in weights remained high, there continued to be disagreement regarding the degree to which nonnative predation influences viability.

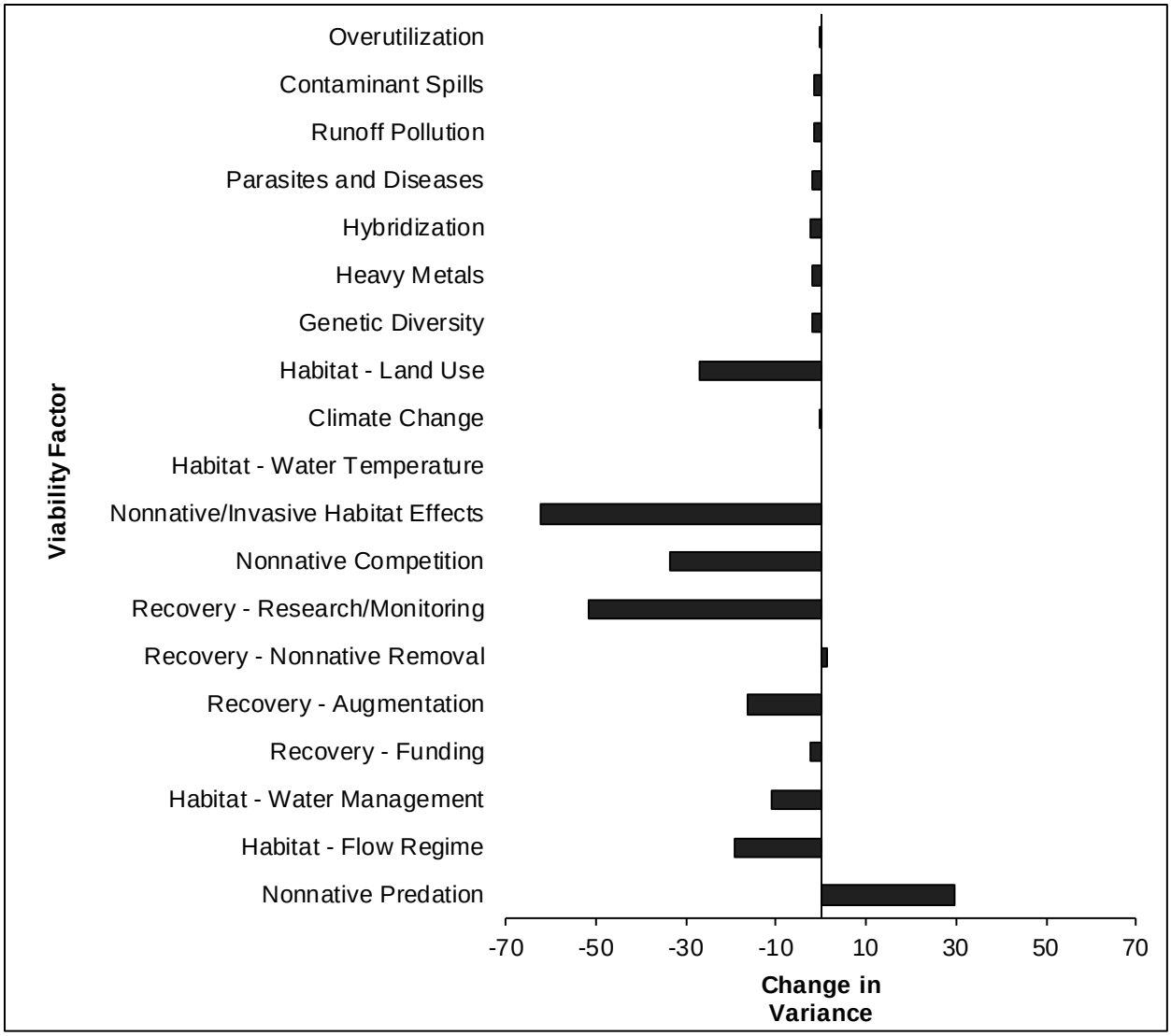


Figure 42. Change in variance for factor weights from Round 1 to Round 3.

The pattern was different for nonnative removal efforts, which also saw slightly increased variability from Round 1 to Round 3 (Figure 21). For this factor, there was notably more change in weights in Round 3. Twelve participants decreased the weight they assigned to this factor while nine increased the weight. The two groups changed their weightings in roughly equal proportions.

The greatest reduction in the variability of scores between Round 1 and Round 3 was for nonnative and invasive habitat effects. Comments regarding this factor indicated that in Round 1 some participants were thinking only about nonnative fish species while others were also thinking about other invasive aquatic species and invasive riparian vegetation such as Tamarisk (the definition provided in the survey intended for this factor to include all of these). Thus, the shared understanding of this factor and other factors likely improved in Round 3, which is one of the purposes of using a Delphi process.

There was little change in variability for the seven lowest ranked factors (genetic diversity, heavy metals, hybridization, parasites and diseases, runoff pollution, contaminant spills, and overutilization), indicating that there was already a high level of agreement in Round 1 that these are less-influential factors on razorback sucker viability.

8.5.3 Factor Weighting Outcomes – Analysis of Variance

A significant difference was found in an analysis of the group's Round 3 mean weights for razorback sucker viability factors (ANOVA, $F_{18,892}=39.0$, $p<0.001$). Based on a consideration of post hoc comparisons (Table 20), the factors can be meaningfully grouped into four tiers of influence on Razorback Sucker viability in the following manner:

- In the top tier of influence are the three factors that the group weighted highest: nonnative predation, and the top two habitat-influencing factors of flow regime and water management. Mean weights for these three factors all exceeded 20 in the Round 3 results.

- The second tier primarily includes conservation and recovery efforts: program funding, augmentation, nonnative removal, and research and monitoring. The group's mean weights for these factors ranged from a high of 17 to a low of 12. Nonnative competition was also included with this tier at the lower end of the range with a mean weight of 12.17.

- The third tier consists of secondary factors that are related to the top tier of factors; these are habitat-quality influencing factors with mean weights between 10 and 3. These factors include habitat effects of nonnatives, water temperature, climate change, land use, and heavy metals. Genetic diversity is also grouped into this tier.

- In the fourth tier are the factors that the group assessed as being the noninfluential factors, at least at the species scale: hybridization, parasites and diseases, contaminant spills, runoff pollution, and overutilization. These factors all had mean weights less than 3. Some participants thought that some of these factors were being underrated by the group or that these factors may have effects for some localized populations, such as hybridization, runoff pollution, and risk of contaminant spills.

8.5.4 Basin Differences in Viability – Multicriteria Analysis Results

As previously stated, participants were also asked to rate factors and subfactors by basins on a 1–5 scale. In the MCA model, ratings by basin were multiplied by the weights assigned to the factors and subfactors to create a composite index by basin. This was done individually by each participant and then averaged for the group. Intuitively, the factor with the highest weight is the most critical one; however, in terms of which factors most distinguish differences between basins, this may not be the case. Instead, it is necessary to examine how sensitive the composite index for each basin was to the composite weights of each factor. This is referred to as sensitivity analysis. There are various ways to conduct a sensitivity analysis depending on the assessment method used (Triantaphyllou and Sanchez 1997). In this case, an appropriate indicator is the mean relative weight of each factor (Figure 43). Objectively, this number is the proportionate change in the difference between the composite indices for each basin that would occur if the given factor were excluded from the model. If participants made no distinction between the

Table 20. Post-hoc, all-pairwise comparison analysis based on Tukey's honest significant differences test, Round 3 group weights.

Factor	Mean Weight	Homogeneous Groups[a]*	Shared Group [a]
Nonnative Predation	27.64	A	A
Habitat - Flow Regime	22.77	AB	A
Habitat - Water Management	22.04	AB	A
Recovery - Funding	17.68	BC	C
Recovery - Augmentation	16.92	BC	C
Recovery - Nonnative Removal	13.52	CD	C
Recovery - Research/Monitoring	12.47	CD	C
Nonnative Competition	12.17	CD	C
Nonnative/Invasive Habitat Effects	9.85	DE	E
Habitat - Water Temperature	9.53	DE	E
Climate Change	9.09	DEF	E
Habitat - Land Use	8.28	DEFG	E
Genetic Diversity	5.94	EFGH	E
Heavy Metals	3.67	EFGH	E
Hybridization	2.94	FGH	H
Parasites and Diseases	2.55	GH	H
Contaminant Spills	2.22	GH	H
Runoff Pollution	2.07	GH	H
Overutilization	1.45	H	H

[a] Letters denote groupings of factors in the post-hoc test, so the first three factors share categorization in "Group A," the next five factors all share categorization in "Group C," and so on.

UCRB and LCRB for a given factor, then that factor would have a mean relative weight of zero. Looking at the example of nonnative predation, this factor has a mean relative weight of 0.258. Expressed as a percentage, this value indicates that the group's overall rating differences between the UCRB and LCRB would be 25.8% less if nonnative predation were excluded from the model. Because this value is in the UCRB column, this indicates that the group, on average, rated this factor higher for the UCRB. However, the error bar overlaps zero, reflecting the previously discussed variability in ratings that participants assigned to nonnative predation, as well as variability in how participants rated the influence of this factor for razorback sucker populations in the respective basins, with many rating nonnative predation equally important in both basins.

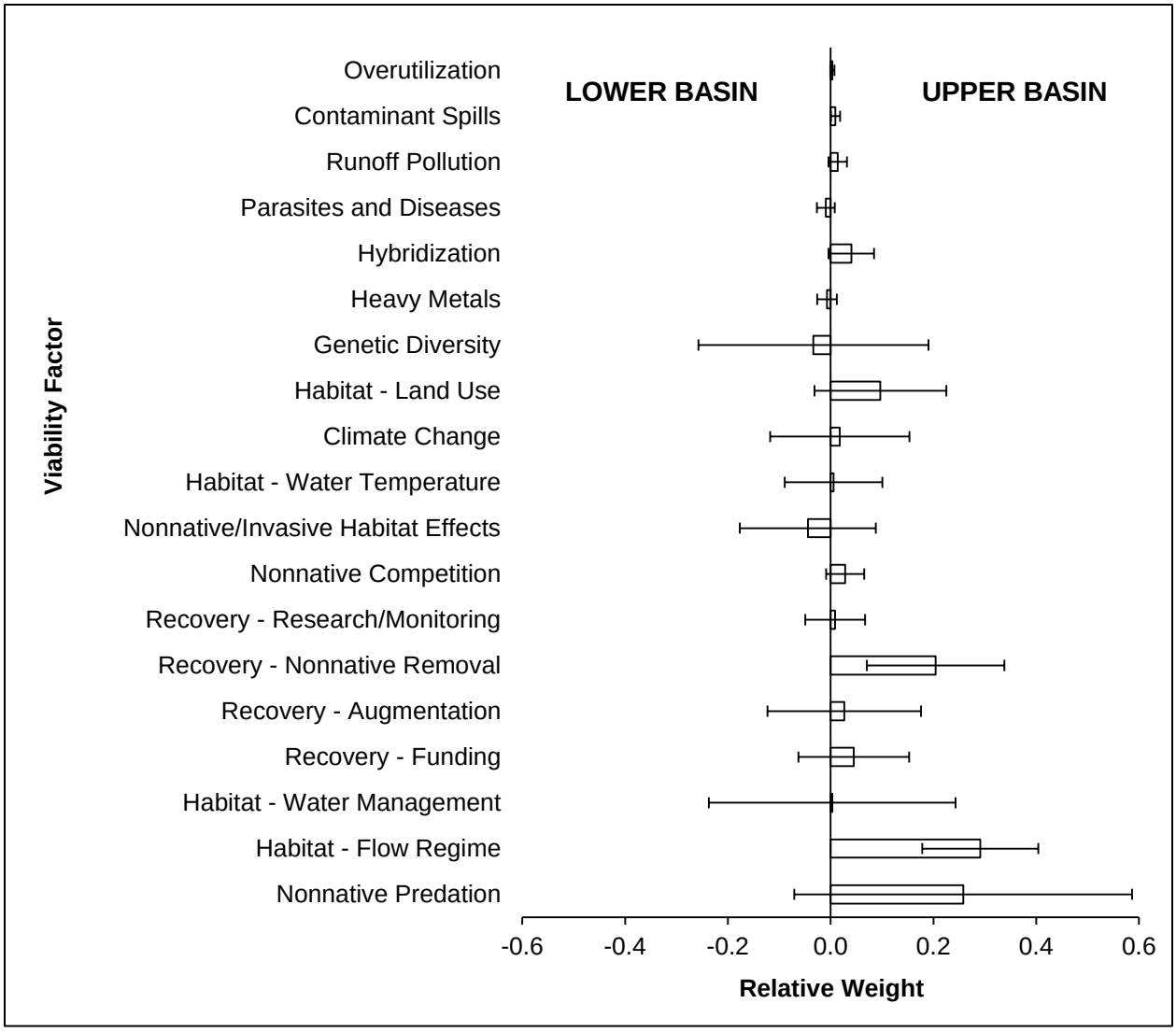


Figure 43. Mean relative weight of factors for the UCRB and LCRB in Round 3 (± 2 Standard Errors).

Looking at all of the factors in Figure 43, the only ones that do not have error bars overlapping zero are flow regime and nonnative removal; thus, participants rated these factors as being more influential in the UCRB. Factors that were perceived as a little more influential in the LCRB were habitat effects of nonnative/invasive species, genetic diversity, heavy metals, and parasites and diseases.

8.5.5 Longer-Term Viability

Finally, as mentioned earlier, participants were asked to rate whether they thought the major categories of factors would become more or less influential 30–100 years in the future. Participants were asked to rate the major factor categories (not subcategories) on a 1–5 scale with 1 representing "less influential," 3 representing "same influence" and 5 representing "more influential." As with the previous assessments, participants rated these factors in Round 1, provided comments regarding their ratings in Round 2, and then had the opportunity to update their ratings in Round 3 based on review of the comments provided by others. As is evident from

the error bars in Figure 44, variability decreased for all of the long-term factor ratings in Round 3 and the group averages shifted slightly. None of the factor averages changed the mean ranked order from Round 1 to Round 3.

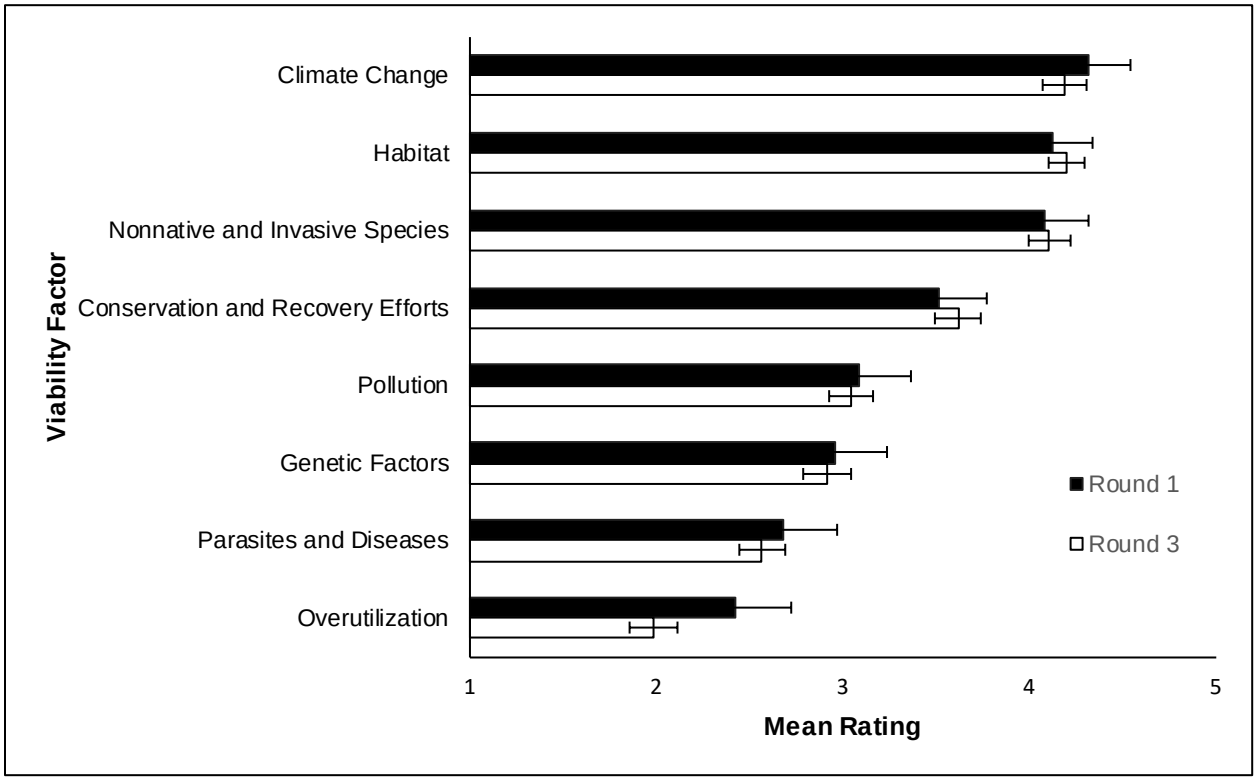


Figure 44. Mean ratings of expected change in influence on viability in 30–100 years on a 1–5 scale with 1 representing "less influential," 3 representing "same influence," and 5 representing "more influential" (±2 Standard Errors).

Participants expected climate change to become more influential in the 30–100 year time frame. Referring back to ratings for the next 30 years, climate change was not expected to be as highly influential in the near term. Participants rated habitat and nonnative species as highly influential in the near term and expected these factors to become more influential in the long term, perhaps because of the relationship of these factors to climate change.

The mean rating for climate change decreased slightly from Round 1 to Round 3 (Figure 44). In Round 2 participants were asked to provide comments for any of their ratings that were one standard deviation higher or lower than the group's average rating. The range of scores in Round 1 was from 3 to 5 on the 1–5 scale, and the group's average rating for climate change was 4.3 with a standard deviation of 0.8. Since the highest possible scale value was 5, there were no ratings that were 1 standard deviation higher; thus only comments supporting a potentially lower rating were provided in Round 2. Those who did not rate climate change as increasingly influential in the 30–100 year period (a rating of 3) explained their rating based on the greater than expected resiliency and adaptability of razorback sucker at the present time, the broad geographic range of the species, and its apparent adaptability to historic climate variability and stochastic events through its evolutionary history. Others thought that climate change may have some positive effects such as providing warmer water where it is presently too cold or possibly

improving habitat as a result of earlier spring flows in some locations. While there was a slight decrease in the group's average rating of climate change in Round 3 (mean = 4.2, standard deviation = 0.7), the majority of participants continued to rate climate change as becoming more influential 30–100 years in the future.

Participants also expected conservation and recovery efforts to continue to influence long-term viability, having the same or an even greater influence beyond 30 years from the present. Thus, participants were not particularly optimistic that razorback sucker would become independently viable in the long term, with wild recruitment being referenced in comments as the necessary element to reduce this need.

Pollution and genetic factors were expected to have the same long-term potential influence as these factors would have in the nearer term. Parasites and diseases, and overutilization were not expected to be longer-term influences and would possibly become even less influential in the 30–100 year time frame as rated by the participants.

8.6 Discussion

In the Delphi process, there was general agreement that nonnative species constrain viability. Habitat, as influenced by flow regime and water management, was also perceived to be a top-tier influence on viability. Habitat is, of course, essential, but some participants thought that habitat was a less important influencer of viability; after Round 3 some participants continued to weight flow regime and water management less than 10. Conversely, none of the participants rated nonnative predation below this level after Round 3. Some perceived that available habitat "is what it is" (i.e., existing populations are surviving within existing habitat limitations). Thus, participants who weighted habitat as low did not expect available habitat or connectivity to be improved over what it is currently.

In the group's assessment, conservation and recovery efforts were rated sufficiently high in influence as to be considered essential to viability. It is reasonable to conclude from submitted comments that biologists working with this species do not believe, on the whole, that the species can persist without interventions continuing into the next 30 years, and likely extending beyond that time period.

Participants saw more constraints on viability in the UCRB, particularly with regard to maintaining a flow regime into the future, and the expected need to continue or increase efforts to remove nonnative fishes. Participants may have perceived LCRB populations to be more viable based on having found a recruiting population in the LCRB and knowledge that fish can be viable in lentic environments. Other recovery efforts (augmentation, research and monitoring, and program funding) were perceived to be essential in both the UCRB and LCRB.

Participants did not rate pollutants or parasites and diseases highly, and there was strong group agreement that these are not among the leading threats to razorback sucker viability. However, some felt that these factors were being underestimated by the group and should not be ignored going into the future.

Similarly, while genetic factors were not perceived as constraining viability of this species, some participants stressed that maintaining genetic diversity with the augmentation program should be continued.

Ratings and comments reflected concern and awareness of climate change and the potential effects this will have on temperature and runoff patterns. Participants were more concerned about the viability effects of climate change in the 30–100 year time frame.

It is also worth discussing comments that participants provided regarding the Delphi process itself. Some participants thought that differences in weights assigned could have been due to differences in the knowledge or confidence of less experienced biologists. In reflecting on their own weightings, some participants did say that they were not confident about their own ratings of the basin in which they had no work experience. Others said that they took the approach of weighting as many of the factors as highly as they could from the perspective of not wanting to ignore a factor and potentially see management efforts decreased in that area (i.e., taking a precautionary perspective). Finally, comments after Round 2 (when participants were able to read comments from others) indicated that there were some obvious misunderstandings of what was being rated for a given factor; examples were land use and habitat effects of nonnative and invasive species.

The Delphi process is intended to address all of these potential sources of error because participants have the opportunity to reflect on all of these methodological aspects (not just the substantive issues) when re-rating factors. Additionally, the technique is an opportunity for participants to learn from one another by taking into consideration the experiences and perspectives of their peers and having the opportunity to then modify their own ratings (Hsu and Sandford 2007; Donohoe and Needham 2009)(Hsu and Sandford 2007; Donohoe and Needham 2009).

In some cases, differences in weights assigned (high variability in weights given to the leading factors) likely reflected a genuine difference of opinion in the field as to which factor is the greater constraint on viability, or they may have reflected basin-centric concerns. However, the final dataset revealed few differences in opinion based on basin-specific work experience. Only the importance of nonnative removal efforts was weighted higher for the UCRB by all participants and by those who primarily worked there.

Much of the remaining variability after Round 3 may have been due to differences in approach to the ranking and weighting method by various participants. In the MCA ranking and weighting exercise, which started by having participants distribute 100 points among 8 major categories of factors, weights exceeding 40 points are substantively large influences because weights this high or higher leave participants with relatively few points to distribute among the other factors. Some participants distributed weights fairly evenly across the top-rated categories of factors (nonnatives, habitat, conservation, and recovery efforts), while others assigned a very high weight (in the 40–60 range) to the category that they thought was the dominant factor. For some that dominant factor was habitat, for others it was nonnatives, and for still others it was conservation and recovery efforts (referring back to Table 7, all of these categories had maximum weights of 60 in Round 1). Likewise, within major factor categories such as

conservation and recovery efforts, some participants weighted augmentation the highest among the subcategories of conservation and recovery efforts while others weighted nonnative removal or research and monitoring higher. Regardless of these idiosyncrasies, the group's average assessment was consistent from Round 1 to Round 3, with the combination of nonnative predation and habitat (as influenced by flow regime and water management) being the top-rated influences on near-term viability, with some combination of conservation and recovery efforts being perceived as essential for maintaining viable populations in the wild in the near-term, and possibly continuing to be needed in the long-term. The perceived greatest influence on long-term viability was the potential effects of climate change.

9 APPENDIX B: RANGE OF FUTURE CONDITIONS TABLE

	Plausible Future Environmental Conditions			
Risk/Cons Action	**Optimistic**			**Pessimistic**
Nonnative Predation	Nonnative predation is actively limited using a variety of techniques including exclusion, population scale efforts, mechanical removal or other novel techniques	Nonnative predation still occurs, but is partially limited by management actions like removal/exclusions	Current nonnative predators continue to limit recruitment in most habitats.	A new predator is introduced to the system and establishes reproducing populations. Expansion or greater abundance of current populations.
Habitat - Flow Regime/Habitat Connectivity	Peak flow management to connect floodplains coincident with presence of larvae expands to more locations. Flows develop and maintain habitat consistent with natural conditions Flows in the lower basin are effectively managed to prevent connections to backwater habitat, yet provide water to fill said habitat	Peak flows allow for biologically driven connections 3 in 5 years. Backwaters are managed to maintain separation from the mainstem channel.	Peak flows allow for biologically driven connections 1 in 5 years. Number or scope of backwaters is reduced because of lack of flow.	Available water is severely reduced, precluding flows to connect wetland environments. Backwater habitat is limited or eliminated by reduced flows and channelization.
Habitat - Water Management	Water management tries to mimic natural conditions, providing ecological benefit and floodplain connection.	Water management continues to incorporate strategies to mimic ecological benefits and floodplain connection.	Additional proactive and adaptive stakeholder management practices continue, but are unable to mitigate the impacts of drought and future water development	Water management is reduced to legally mandated actions and are unable to cope with reduced stream flows or increases in variability such that providing ecological benefit is rare.
Recovery - Funding	Funding remains at current levels and adaptive management allows for more effective use, increasing funding effectiveness	Funding remains at current levels and activities remain consistent with current planning efforts	Some funding remains, but at reduced levels	Conservation programs are no longer in place, with the exception of legally mandated actions (enforced outside of the ESA)
Recovery - Augmentation	Stocking ceases because of wild recruitment	Stocking/reintroduction continues at levels deemed optimal for species support	Stocking/reintroduction remains, but becomes limited in scope due to lack of funds	Stocking ceases due to lack of funds
Recovery - Nonnative Removal/Control	Nonnative populations are managed through population scale efforts, i.e. spike flows where possible Additional backwaters are developed and actively managed to exclude nonnative fish.	Nonnative populations are controlled using mechanical means where possible Backwaters are actively managed to exclude nonnative fish.	Mechanical removal of nonnative continues, but at a reduced level, where possible Development and management of backwater habitat is limited by lack of funds	Nonnative management/removal ceases due to lack of funds Management of backwaters reduced because of lack of funds
Recovery - Research/Monitoring	Monitoring expands to include population estimates and life-stage monitoring. Funds are available to determine species bottlenecks and support adaptive management	Monitoring continues in conjunction with other efforts. Some novel research is available	Monitoring continues in conjunction with other efforts, but is limited in scope.	Monitoring ceases. Due to lack of funds, is handed to states in conjunction with other multi-species surveys.
Nonnative Competition	Nonnative fish add interference or resource competition pressures– currently unmanageable background effect			Nonnative fish use niche space that could be available for razorback sucker – currently unmanageable background effect
Nonnative habitat effects	Floodplains are kept free from invasive vegetation, tamarisk and Russian olive contained rangewide			Invasive vegetation expand in scope and limits access to nursery habitat
Climate Change - *30 to 100 years only*	Reductions in stream flows are managed through voluntary/program efforts with little ecological degradation from current conditions			Reduced winter snowpack and late winter and early spring precipitation would likely result in an earlier and shorter runoff period.

EXHIBIT 39

SEVEN COUNTY INFRASTRUCTURE COALITION, UTAH
INDUCEMENT RESOLUTION
PRIVATE ACTIVITY BONDS

May 8, 2025

RESOLUTION NO. 2025-05A

RESOLUTION AUTHORIZING AND INDUCING THE EXECUTION OF A MEMORANDUM OF INDUCEMENT AGREEMENT WITH DREXEL HAMILTON INFRASTRUCTURE FUND II, LLC AND UINTA BASIN RAILWAY HOLDINGS, LLC, OR ANY AFFILIATE ENTITIES THEREOF REGARDING THE ISSUANCE OF PRIVATE ACTIVITY BONDS IN AN AMOUNT NOT EXCEEDING $2,400,000,000 TO FINANCE RAIL SURFACE TRANSPORTATION AND FREIGHT TRANSFER FACILITY AND RELATED IMPROVEMENTS; PROVIDING FOR THE PUBLICATION OF A NOTICE OF PUBLIC HEARING AND BONDS TO BE ISSUED; AND RELATED MATTERS.

WHEREAS, Seven County Infrastructure Coalition, Utah (the "Issuer"), is a separate and independent political subdivision authorized and created under the Utah Interlocal Cooperation Act, Title 11, Chapter 13, Utah Code Annotated 1953, as amended (the "Interlocal Act") pursuant to resolutions of each of its member counties consisting of Carbon, Daggett, Duchesne, Emery, San Juan, Sevier, and Uintah counties approving an Amended Interlocal Agreement dated as of and effective as of December 1, 2016 (the "Interlocal Agreement"); and

WHEREAS, pursuant to paragraph 6.1.F of the Interlocal Agreement and as noted in the authorizing or approving resolutions of each member county, the Issuer is authorized to borrow money and incur indebtedness and to issue bonds for the purposes of the Issuer, which includes a rail surface transportation and freight transfer facilities project; and

WHEREAS, the Issuer, as authorized by its member counties through the Interlocal Agreement, is authorized and empowered by the provisions of the Interlocal Act to issue revenue bonds or other forms of revenue financing (the "Bonds") to make the most efficient use of their powers by enabling them to cooperate on a basis of mutual advantage and thereby to provide services and facilities in a manner that will accord best with geographic, economic, population and other factors influencing the needs and development of local communities and to provide the benefit of economy of scale, economic development, and utilization of natural resources for the overall promotion of the general welfare of the public agencies and the state of Utah; and

WHEREAS, the Issuer has previously entered into agreements with Drexel Hamilton Infrastructure Partners, L.P. and its successor Drexel Hamilton Infrastructure Fund II, LLC (collectively, "DHIP") to finance, own, construct, operate and maintain rail

facilities, including freight transfer facilities, subject to compliance with certain terms and conditions set forth therein; and

WHEREAS, DHIP, in conjunction with one or more of its affiliated entities, including Uinta Basin Railway Holdings, LLC, Uinta Basin Railway, LLC and Uinta Basin Terminal, LLC (collectively, "UBRH") desires to induce the Issuer to sponsor and issue limited obligation private activity bonds to help fund the rail surface transportation and freight transfer facilities project and related improvements in an amount of not more than $2,400,000,000; and

WHEREAS, in order to achieve the purposes of the Issuer, as authorized by its members and by the Interlocal Act, the Issuer desires to help finance the acquisition, construction, and equipping of a rail surface transportation and freight transfer facilities and related improvements, generally described in Exhibit "C" attached hereto (the "Project"). The Project will be owned and operated in whole or in part by DHIP or an affiliated entity, such as UBRH, which is owned and controlled by DHIP, or any affiliate entity thereof (the "Borrower"); and

WHEREAS, the Borrower is reluctant to take steps toward the construction of the Project without satisfactory assurance from the Issuer that the proceeds of the sale of the Bonds of the Issuer will be made available to finance the acquisition, construction, and equipping of the Project; and

WHEREAS, it is deemed necessary and advisable for the development, welfare and prosperity of the Issuer and its inhabitants and a benefit to the state of Utah that the Project be acquired and constructed, and that the Issuer take such action as may be required under applicable statutory provisions to authorize and issue its Bonds to finance the Project in an amount not exceeding $2,400,000,000; and

WHEREAS, the Bonds shall be limited obligations of the Issuer and at no time will they constitute a pledge of the general taxing powers or credit of the Issuer, of any member county, or of the State of Utah or any political subdivision of the state of Utah; and

WHEREAS, a form of agreement, hereafter designated as a "Memorandum of Inducement Agreement," has been prepared under which the Borrower has stated its willingness to promptly acquire and construct the Project; and

WHEREAS, it is considered necessary and desirable and in the best interests of said Issuer that execution of said Memorandum of Inducement Agreement be authorized for and on behalf of the Issuer; and

WHEREAS, the Interlocal Act provides for the publication of a Notice of Public Hearing and Bonds to be Issued, and the Issuer desires to publish such a notice at this time in compliance with the Interlocal Act with respect to the Bonds:

NOW, THEREFORE, Be It Resolved by the Governing Board of the Seven County Infrastructure Coalition, Utah (the "Governing Board"), as follows:

Section 1. In order to assure that the Borrower finance, construct, operate and maintain the Project with the resulting public benefits which will flow therefrom, including economic development, it is deemed necessary and advisable that the Memorandum of Inducement Agreement hereinafter attached, be approved and executed for and on behalf of the Issuer.

Section 2. The Memorandum of Inducement Agreement by and between the Borrower and the Issuer in substantially the form and with the contents set forth in Exhibit "B" attached hereto, is hereby approved and the execution thereof is hereby authorized. The Executive Director of the Issuer is authorized to sign the Memorandum of Inducement Agreement with such corrections, changes and amendments as the Executive Director deems necessary or desirable and the application of the signature of the Executive Director shall be conclusive evidence that the Issuer has accepted and agreed to such corrections, changes and amendments. The Issuer's Secretary is authorized to attest to the signature of the Executive Director and to apply the seal of the Issuer to the Memorandum of Inducement Agreement.

Section 3. In accordance with the provisions of the Act, the Secretary shall cause the following "Notice of Public Hearing and Bonds to be Issued" to be published one (1) time in the Deseret News, a newspaper of general circulation in the Issuer, and shall cause a copy of this Resolution (together with all exhibits hereto) to be kept on file in the Secretary's office, for public examination during the regular business hours of the Governing Board until at least thirty (30) days from and after the date of publication thereof. The "Notice of Public Hearing and Bonds to be Issued" shall be in substantially the following form:

NOTICE OF PUBLIC HEARING AND BONDS TO BE ISSUED

NOTICE IS HEREBY GIVEN pursuant to the provisions of the Utah Interlocal Cooperation Act, Title 11, Chapter 14, Utah Code Annotated 1953, as amended, that on May 8, 2025, the Governing Board (the "Governing Board") of Seven County Infrastructure Coalition, Utah (the "Issuer") adopted an inducement resolution (the "Resolution") in which it expressed its intent to issue Private Activity Bonds in the aggregate principal amount of not to exceed Two Billion Four Hundred Million Dollars ($2,400,000,000) (the "Bonds") to finance the acquisition, construction, and equipping of a rail surface transportation and freight transfer facilities, and related improvements (the "Project"). The Project will be owned and operated in whole or in part by Drexel Hamilton Infrastructure Partners Fund II, LLC, or its affiliate Uintah Basin Railway Holdings, LLC, or an affiliate entity thereof, including Uinta Basin Railway, LLC and Uinta Basin Terminal, LLC (the "Borrower").

NOTICE IS FURTHER GIVEN that the Issuer hereby calls a public hearing with respect to the Bonds on June 12, 2025, at 10:00 a.m., with an anchor location at the Carbon County Commission Chambers at 751 E. 100 N., Price, Utah, and a satellite location connected by electronic transmission in Room 450 at the State Capitol located at 350 State Street in Salt Lake City, Utah. The Borrower intends to finance, acquire, and construct rail surface transportation facility and related improvements from the Kyune, Utah area near Soldier Summit in Utah County to the Uinta Basin area, including freight transfer facilities (the "Project"). This Project involves the financing, acquisition and construction of the rail and related improvements. All members of the public are invited to attend and participate in person or by written comment.

The Bonds are to be issued pursuant to the Resolution and a Final Bond Resolution which authorizes an Indenture of Trust or similarly related document (collectively, "Final Bond Resolution") to be adopted authorizing and confirming the sale of the Bonds for the purpose of financing the Project, establishing associated funds, and paying issuance expenses to be incurred in connection with the issuance and sale of the Bonds.

The Bonds are to be issued and sold by the Issuer pursuant to the Resolution, including as part of said Resolution the draft of a Final Bond Resolution which was before the Governing Board and attached to the Resolution in substantially final form at the time of the adoption of the Resolution (collectively, the "Bond Resolution") and said Final Bond Resolution is to be adopted by the Governing Board in such form and with such changes thereto as shall be approved by the Governing Board upon the adoption thereof. The proposed Bonds will not constitute general obligations of the Issuer, any of its member counties, of the State of Utah or any public body. The Issuer will not be obligated to pay costs incurred in connection with the issuance of the Bonds nor will it be liable to make payments of interest or principal on the Bonds.

A copy of the Resolution and the Final Bond Resolution are on file in the office of the Secretary of the Issuer at 751 E., 100 N., Price, Utah which is also the office of the Carbon County Clerk/Auditor, where they may be examined during regular business

hours of the Carbon County Clerk/Auditor and Secretary from 8:00 a.m. to 5:00 p.m. for a period of at least thirty (30) days from and after the date of publication of this notice.

NOTICE IS FURTHER GIVEN that a period of thirty (30) days from and after the date of the publication of this notice is provided by law during which any person in interest shall have the right to contest the legality of the Bond Resolution or the Bonds, or any provision made for the security and payment of the Bonds, and that after such time, other than referendum rights, no one shall have any cause of action to contest the regularity, formality or legality thereof for any cause whatsoever. This public hearing is required by the Federal Tax Reform Act of 1986. Comments at the public hearing are invited. Written comments may be submitted to the Issuer to its Secretary at the office of the Secretary and the Carbon County Clerk/Auditor at 751 E. 100 N. in Price, Utah. Additional information can be obtained from the Issuer by calling (801) 520-5333.

DATED May 8, 2025.

/s/ Stacey Herpel
Secretary

Section 4.

The Governing Board hereby directs the officials and staff of the Issuer to cooperate with and assist the Issuer's bond counsel, The Stratton Law Firm, PLLC and co-bond counsel, Foley & Lardner LLP, and associated professionals, including the Issuer's municipal advisor, Cody Deter of EFG Consulting, LLC, to prepare documents and other certificates and opinions reasonably necessary to issue the Bonds.

Section 5. The Issuer hereby declares its intention and it reasonably expects to reimburse expenditures with bond proceeds in accordance with Treasury Regulation § 1.150-2.

Section 6. All resolutions and parts thereof in conflict herewith are hereby repealed to the extent of such conflict.

Section 7. The Governing Board directs the Secretary to complete the attached Record of Proceedings.

Section 8. The Governing Board considers that this resolution is necessary and in the best interest of the Issuer, and therefore, it shall become effective immediately upon its passage, approval and adoption.

Passed and approved this May 8, 2025, by the Governing Board of Seven County Infrastructure Coalition, Utah.

SEVEN COUNTY INFRASTRUCTURE COALITION, UTAH

CO-CHAIR

CO-CHAIR

ATTEST:

Secretary

(SEAL)

SEVEN COUNTY INFRASTRUCTURE COALITION SEAL UTAH

EXHIBIT A
RECORD OF PROCEEDINGS

The Governing Board of the Issuer met in public session at the Governing Board's special meeting place at Room 450 in the State Capitol at 350 State Street, Salt Lake City, Utah on May 8, 2025 (the "Meeting"), at the hour of 10:00 a.m., or as soon thereafter as feasible, with the following members of the Governing Board being present:

Greg Miles	Co-Chair - Duchesne
Jack Lytle	Co-Chair - Daggett
Jared Haddock	Board member - Carbon
Sonja Norton	Board member – Uintah
Dennis Worwood	Board member – Emery
Silvia Stubbs	Board member – San Juan
Greg Jensen	Board member - Sevier

Also present:

Keith Heaton	Executive Director
Stacey Herpel	Secretary

Absent:

which constituted all the members thereof.

After the Meeting had been duly called to order and after other matters were discussed, the foregoing resolution (the "Resolution") was introduced in written form and fully discussed.

A motion to adopt the Resolution was then duly made by Jensen and seconded by Miles, and the Resolution was put to a vote and carried, the vote being as follows:

VOTING:		
	Carbon	Yea ✓ Nay ___
	Daggett	Yea ✓ Nay ___
	Duchesne	Yea ✓ Nay ___
	Emery	Yea ___ Nay ___ Excused
	Sevier	Yea ✓ Nay ___
	San Juan	Yea ✓ Nay ___
	Uintah	Yea ✓ Nay ___

Those Abstaining:

Other business not pertinent to the Resolution appears in the minutes of the Meeting. Upon the conclusion of all business on the Agenda and motion duly made and carried, the Meeting was adjourned.

CERTIFICATE OF COUNTY CLERK/AUDITOR

I, Stacey Herpel, the duly appointed and qualified Secretary of the Issuer, do hereby certify that the attached Resolution is a true, accurate and complete copy thereof as adopted by the Governing Board at a public meeting duly held on May 8, 2025 (the "Meeting"). The persons present and the result of the vote taken at the Meeting are all as shown above. The Resolution, with all exhibits attached, was deposited at the office of the Secretary and Carbon County Clerk/Auditor at 751 E. 100 N., in Price, Utah, on May 8, 2025 and is officially of record in my possession.

I further certify that, pursuant to the Resolution, I caused to be published a "Notice of Public Hearing and Bonds to be Issued" one (1) time in the Deseret News a newspaper having general circulation in the Issuer. An affidavit of publication of such notice shall be attached hereto.

IN WITNESS WHEREOF, I have hereunto subscribed my signature and impressed hereon the official seal of the Issuer, this May 8, 2025.

(SEAL)

SEVEN COUNTY INFRASTRUCTURE COALITION
SEAL
UTAH

Secretary

(ATTACH AFFIDAVIT OF PUBLICATION OF PUBLIC HEARING AND NOTICE OF INTENT TO ISSUE BONDS)

CERTIFICATE OF COMPLIANCE WITH
OPEN MEETING LAW

I, Stacey Herpel, the undersigned Secretary of the Issuer do hereby certify, according to the records of the Issuer in my official possession, and upon my own knowledge and belief, that in accordance with the requirements of Section 52-4-6(2), Utah Code Annotated, 1953, as amended, I gave not less than twenty-four (24) hours public notice of the agenda, date, time and place of the May 8, 2025 public meeting held by the governing body of the Issuer as follows:

(a) By causing a notice, in the form attached hereto as Schedule 1 (the "Meeting Notice"), to be posted at the principal office of the Issuer at least 24 hours prior to convening the meeting, the Meeting Notice having continuously remained so posted and available for public inspection until the completion of the meeting; and

(b) By causing a copy of the Meeting Notice to be delivered to a newspaper of general circulation in the geographic jurisdiction of the Issuer at least twenty-four (24) hours prior to the convening of the meeting.

(c) By causing a copy of the Meeting Notice to be posted on the Utah Public Notice Website at least 24 hours prior to convening the meeting.

(d) By causing a copy of the Meeting Notice to be delivered to each of the members of the governing body by electronic means.

In addition, the Notice of 2025 Annual Meeting Schedule for the Issuer, attached hereto as Schedule 2, specifying the date, time and place of the regular meetings of the governing body of the Issuer to be held during the calendar year 2025 was (1) posted on Jan 1, 2025, at the principal meeting place of the Issuer at 751 E. 100 N., Price, Utah and (2) provided to at least one newspaper of general circulation within the geographic jurisdiction of the Issuer on Jan 1, 2025, and (3) posted on the Utah Public Notice Website on Jan 1, 2025.

IN WITNESS WHEREOF, I have hereunto subscribed my official signature this May 8, 2025.

SEVEN COUNTY INFRASTRUCTURE COALITION SEAL UTAH

(SEAL)

Stacey Herpel
Secretary

[Attach Schedule 1, Meeting Notice]

[Attach Schedule 2, Annual Meeting Notice]

EXHIBIT A

NOTICE OF ANNUAL MEETING SCHEDULE OF THE SEVEN COUNTY INFRASTRUCTURE COALITION 2025

For 2025, the Board of the Seven County Infrastructure Coalition, Utah, will hold its regular meeting at 10:00 a.m., or as soon thereafter as feasible, the second Thursday of each month, except as noted below. See below.

DATES

January 9, 2025	* February 13, 2025
March 13, 2025	April 10, 2025
May 8, 2025	June 12, 2025
July 10, 2025	August 14, 2025
September 11, 2025	October 9, 2025
November 13, 2025	December 11, 2025

Meetings will be held in person at the Carbon County Commission Chambers, located at 751 East 100 North, Price, Utah 84501, please double check meeting locations on the Seven County website (7countyUtah@gmail.com) prior to monthly meetings. Questions or concerns should be directed to Stacey Herpel, 435-817-0025

*Location to be Announced

Gmail

Stacey Herpel <stacey@7county.utah.gov>

Public Notice Updated for Governing Board

1 message

support@helpdesk.utah.gov <support@helpdesk.utah.gov> Tue, May 6, 2025 at 10:36 PM
To: stacey@7county.utah.gov

Utah Public Notice

Revised Notice

Governing Board

SCIC 2025 Meeting Schedule

Notice Date & Time: 1/1/25 10:24 PM

Description/Agenda:

EXHIBIT A

NOTICE OF ANNUAL MEETING SCHEDULE OF THE
SEVEN COUNTY INFRASTRUCTURE COALITION
2025

For 2025, the Board of the Seven County Infrastructure Coalition, Utah, will hold its regular meeting at 10:00 a.m., or as soon thereafter as feasible, the second Thursday of each month, except as noted below. See below.

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* February 13, 2025
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Meetings will be held in person at the Carbon County Commission Chambers, located at 751 East 100 North, Price, Utah 84501, please double check meeting locations on the Seven County website (7countyUtah@gmail.com) prior to monthly meetings. Questions or concerns should be directed to Stacey Herpel, 385-337-0033
*Location to be Announced

Notice of Special Accommodations:

In compliance with the Americans with Disabilities Act, individuals needing special accommodations (including auxiliary communicative aids and services) during this meeting should notify Stacey Herpel @ 385-337-0033 or stacey@7county.utah.gov

Notice of Electronic or telephone participation:

None

Other information:

Location:

751 East 100 North, Price, 84501

Contact information:

Stacey Herpel , stacey@7county.utah.gov, 385-337-0033

EXHIBIT "B"

MEMORANDUM OF INDUCEMENT AGREEMENT

[See Transcript Document No. ___]

EXHIBIT "C"

PROJECT DESCRIPTION

Finance, acquire, and construct rail surface transportation facility and related improvements from the Kyune, Utah area near Soldier Summit in Utah County to the Uinta Basin, including freight transfer facilities and related improvements consistent with approval from the U.S. Surface Transportation Board dated December 15, 2021, including any amendments thereto.

EXHIBIT "D"

FORM OF FINAL BOND RESOLUTION

[See Transcript Document No. ___]

EXHIBIT 40

An official website of the United States government Here's how you know

United States Department of Transportation

In This Section

Related Links

- Applications for Authority for Tax - Exempt

Build America Bureau

1200 New Jersey Ave SE
Room W12-426
Washington, DC 20590

Email:
BuildAmerica@dot.gov
Phone: 202-366-2300
Business Hours:
9:00am- 5:00pm ET, M-F

If you are deaf, hard of hearing, or have a speech disability, please dial 7-1-1 to access telecommunications relay services.

Private Activity Bonds

The U.S. Department of Transportation (USDOT) Private Activity Bonds (PABs) Program is a key financing tool to support private sector participation and investment in critical transportation infrastructure projects nationwide. Public-private partnerships (P3s) generate new sources of funding and financing (private equity and debt) as well as efficiency and innovation in project design and delivery. Providing private sector infrastructure developers and operators with access to tax-exempt debt lowers the cost of capital for these large and expensive projects, enhancing their investment prospects.

As a tax-exempt debt instrument[1], PABs offer a financing option at a lower cost than comparable taxable bonds for a range of transportation projects that are privately developed, built, financed, operated, and/or maintained utilizing P3 project delivery methods. The types of projects that qualify for PABs that USDOT allocates include a broad range of surface transportation projects, including highways, passenger rail, and surface freight transfer facilities. Please see Private Activity Bonds - Eligibility for more detailed information.

Most PAB applications are submitted by State DOTs early in a P3 procurement process on behalf of the to-be-selected private developer. The approved allocations provide firms bidding for the project with assurance that this low-cost financing will be available to make the project more affordable. The PABs that USDOT allocates to projects are issued on capital markets by state/local (i.e., public sector) conduit agencies on behalf of the private developers who are responsible for debt repayment from either the project-generated revenues or from the availability payments they receive from the project owner/grantor. As such, this financing tool is not a form of federal financial assistance. Please see Private Activity Bonds - Applications for more information about applying.

Examples of projects that benefited from the PABs Program include high-speed commuter and passenger rail lines, urban transit, and thousands of miles of new express/managed lanes throughout the country. These projects provide the traveling public with fast and comfortable mobility options, reducing congestion on the nation's road network. PABs have also financed old bridge replacements and a transfer facility supporting the movement of cargo and goods from rail to truck and truck to rail.

The USDOT is authorized to allocate up to $30 billion in PABs. Please see Private Activity Bonds - Allocations for all allocations to date.

Allocations (as of November 1, 2025)

- Total authorized: $30 billion
- Total allocated and issued: $23.9 billion
- Total allocated and yet-to-be issued: $6.1 billion

- Total currently available to be allocated: $0

Private Activity Bond Resources

Federal Register Notice

https://www.gpo.gov/fdsys/pkg/FR-2006-01-05/pdf/E5-8306.pdf
View the Federal Register notice inviting comments on and applications for Authority for Tax-Exempt Financing of Highway Projects and Rail-Truck Transfer Facilities.

Federal Register Docket

https://www.gpo.gov/fdsys/pkg/FR-2006-01-05/html/E5-8306.htm
This location provides background documents and comments received on the Federal Register Notice. It is updated as new documentation and comments are received.

SAFETEA-LU Fact Sheets, Guidance, and Regulations

http://www.fhwa.dot.gov/safetealu/reference.htm
To view resource materials on Private Activity Bonds, use this link and navigate to the entry for Section 11143 Tax-Exempt Financing of Highway Projects and Rail-Truck Transfer Facilities.

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[1]Under Section 103(a) of the Internal Revenue Code, interest on qualified private activity bonds (similarly to governmental bonds issued by states and local governments) is not taxed by the Federal government. This feature makes such bonds more attractive for purchase. Lenders are willing to accept a lower interest rate on the bond, which lowers the cost of borrowing for the issuer.

Last updated: Wednesday, December 10, 2025

U.S. Department of Transportation
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EXHIBIT 41

SEVEN COUNTY INFRASTRUCTURE COALITION
MEETING MINUTES
October 9, 2025 at 10:00 a.m.
Carbon County Commission Chamber (Anchor Location + Electronic)
751 East 100 North
Price, Utah 84501
(801) 712-7622

Board Members Present: Jared Haddock (Carbon County), Dennis Worwood (Emery County), Greg Jensen (Sevier County), Sonja Norton (Uintah County), Silvia Stubbs (San Juan County), Greg Miles (Duchesne County), and Jack Lytle (Daggett County).
Also in attendance: Keith Heaton, Brian Barton, Michael Hawley, Jon Stearmer, Melanie Sasser, Doug Rasmussen, Dan Hawley, Tom Davidson, Steve Rodgers, Jeff Worthington, and Mike Bean.
Attended telephonically: Kelly Carter, Stacey Herpel, Melissa Cano, Joel Brown, Heather Poulsen, Candace Powers, John Laursen, Will Lane, and Willis LeFevre.
Others Present: (Please notify staff at 435-817-0025 of any spelling corrections or if you were present and not listed.)

Public Meeting Participation Information:
Please click the link below to join the webinar:
https://jonesanddemille.zoom.us/j/81812623532

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1-253-215-8782 or
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Webinar ID: 818 1262 3532

1. Welcome and Pledge of Allegiance (Jack Lytle)

Chairman Lytle welcomed everyone to the meeting at 10:10 AM. Chairman Lytle led the pledge of allegiance and had everyone introduce themselves.

2. Public Comment (Jack Lytle)

Public comment was accepted verbally, during the meeting, telephonically by Zoom, and by electronic written submission at stacey@7county.utah.gov. Electronic written comments will be forwarded to the Board Members. All comments are summarized in the meeting minutes. A complete copy of any written comments submitted may be requested at the email address provided herein. Chairman Lytle then turned time over to Melissa Cano for those wishing to make public comments electronically.

There were no public comments online or in the room at this time.

Chairman Lytle thanked Ms. Cano and handed the time over to Chairman Miles. Chairman Miles then moved to the next item on the agenda.

3. Approval of Meeting Minutes for September 26, 2025 (Greg Miles)

Chairman Miles inquired about changes or updates to the minutes, Commissioner Norton stated there were some grammatical corrections, and Commissioner Miles stated another correction. Ms. Herpel stated that those corrections are noted and will be done prior to posting approved meeting minutes. Chairman Miles requested a motion to approve the minutes with amendments.

Motion to approve, September 26, 2025 meeting minutes as amended, by Commissioner Jensen and seconded by Commissioner Lytle.

Chairman Miles called for a vote to approve the minutes as amended. **The motion passed unanimously.**

4. County Project Updates (Board Members)

Chairman Miles stated that he will turn the time over to the board members for any project updates at this time.

There were no updates from the County Commissioners at this time and the updates were deferred to Director Heaton.

Chairman Miles thanked the commissioners and turned the time over to Director Heaton.

5. Executive Director Report (Keith Heaton)

Chairman Miles turned time over to Director Heaton for the director's report and county project updates. Director Heaton thanked the chairman and the board. Director Heaton thanked everyone for being here today, he appreciates all the support both in person and those online.

Director Heaton went on to state that the we are still waiting on a decision from the DC Circuit Court to the Surface Transportation Board on the Railway. This is taking longer than anticipated, but we hope to hear something any day. The courts have a different funding, which comes in part through fees and the Federal Government shutdown should not impact the decision time. Our private partners on the railway, Drexel Hamilton Infrastructure Partners, are exploring the option of applying for a federal loan, since there is a shortage of private activity bonds, to help offset the difference. The application is for the RRIF program. This is being encouraged by the Department of Transportation, there will be more updates to come.

Director Heaton stated that another project we have been actively working on is the deep water throughput capacity port. There are multiple options that we are exploring at this time and we are in the process of working on an application to the Throughput Infrastructure Fund, which is administered through the Community Impact Board. The intent is to submit a phase one application for them to review next month. This is to explore various options that we are currently working on, including the original project site. This is a separate fund from the Community Impact Board fund, so many of the rules do not apply as it is not a CIB project.

Director Heaton stated that at our last meeting, we had scheduled a meeting with the Ute Business Committee. They have postponed that meeting due to many of their members traveling out of the area, they have not given us a reschedule date. We will continue to stay on top of that and hopefully get something and let everyone know as soon as we hear back from them.

Director Heaton stated that with the Jensen Water Project there was not too much to update on at this time, there is a meeting scheduled next week and we hope to have additional information at the next meeting. The funding applications are all in place with both the federal and state sources. The project is looking positive at this time. We attended the Basin Energy Summit and there was a lot of conversation about that project and the need for additional water to meet current and future demands.

Director Heaton stated that there were some good conversations at the Energy Summit about the Greendale Resort Project. We will be scheduling meetings shortly to continue to push forward with this project. The intent is that we will put together a consortium of interested parties to move it forward, we remain optimistic that it will happen.

Director Heaton stated that next week in San Juan County, Energy Fuels is holding an open house, thanks to Jones and DeMille, Scott Flannery will attend as a representative for the

Infrastructure Coalition. Many things are happening at Energy Fuels and we will continue to support them in any way we can, including exploring rail options and other ways to transport materials. There are many projects happening in San Juan County and we will continue to support those as best we can.

Director Heaton stated that this concludes his updates for the current and active projects that we have going on at this time, he would be happy to answer any questions.

Chairman Miles thanked Director Heaton. Chairman Miles stated that he attended the One Utah Summit and one of the breakout sessions and the topic was on nuclear. One of the panelists was from Energy Fuels, along with Emmy Lesofsky in the Office of Energy, then another woman from Canada that had worked at a nuclear plant for 20 years, and Directory Ferry. They talked about the good things that are happening at the San Rafael Research Lab, Emmy Lesofsky pointed out that it is filling up fast. They have got a lot of interested parties, because they can actually do their research at the lab. Chairman Miles wanted to point out this highlight and that it has become a big success of the coalition.

Commissioner Worwood stated that Valor is building one of their buildings and have their modular reactor tested and approved by July 4, 2026. Valor is looking to hire 30 people at their expanded campus near the research lab.

Director Heaton stated that the original intent was that the Energy Lab could partner with the Idaho National Lab, as they did not have the capacity to handle all of the lab work that needed to be done. So we intentionally designed this to take overflow from the Idaho National Lab. Now we have almost maximized the existing capacity in just a few short years. Director Heaton appreciated everyone who had the vision and participated in the early stages of this project.

Chairman Miles then called for any additional questions for Director Heaton. Chairman Miles then moved on to the next agenda item.

6. Engineers Report (Jones & DeMille)

Chairman Miles turned the time over to Brian Barton with Jones & DeMille for the Engineers Report. Mr. Barton stated that they sent out a memo yesterday to all the commissioners. This is a common report, technical report from Jones and DeMille, that we are providing the technical backup and muscle behind all the things that Director Heaton described. This report includes funding coordination applications, supporting documents to support all those efforts, and budget tracking.

Mr. Barton stated that we continue with the budget tracking on the rail and where we are at with that project. We need to be mindful of what is left in the budget and what is yet to be done. As soon as we have the DC Circuit Court’s decision and that case is sent back to the STB, we can

have a clearer picture of the budget. We are ready to scope that out with all the involved parties and get through it as quickly as possible on the engineering side. Mr. Barton stated that is all that he has at this time.

Mr. Barton stated that with the communications report coming up next, he would like to bring up a type of branding for the coalition. Telling the coalition stories is a big deal. Helping everybody else outside of this room to understand the impact and the value that the coalition brings to these critical initiatives for the state and the nation.

Chairman Miles thanked Jones & DeMille for their update and all the work they have been doing. Chairman Miles asked if there were any more questions about the Engineering Report, seeing none, he then moved on to the next agenda item.

7. Communications Report (Melissa Cano)

Chairman Miles turned the time over to Melissa Cano for the communications report. Ms. Cano thanked Chairman Miles and stated that we did talk briefly about revamping what branding could and would look like for the coalition. There will be more updates to come.

Ms. Cano stated that she is going to meet with Director Heaton first and show him a couple of ideas in the next month and then from there we will get that rolling. Ms. Cano stated that from previous conversations we want to be more forward, this is a good moment and achievement to take that forward and then the actual update will piggyback on what was just discussed. Ms. Cano thinks that once the DC Circuit Court makes the decision, it will become noisy again on the comment side for the railway and we anticipate some follow-up actions from that. At this moment, we are keeping quiet.

Ms. Cano stated that there was no stakeholders meeting last month, but we will regroup with everyone next month. This is all the update she has at the moment and is willing to answer any questions.

Commissioner Stubbs stated that in our local areas the public checks our budgets to see where we are at and where we are going. Commissioner Stubbs asked if there was a way to promote Seven County meetings and explain some of the benefits that are received for being a part of the coalition. We do not want to give away secrets or not sure if we are allowed to talk about this. If we could have an outline, it would help us as we report where we have been and try to promote Seven Counties in our areas or other areas.

Ms. Cano thanked Commissioner Stubbs and stated that she has been thinking up for next steps as well as next year. We can include paid advertising to your point, but that would obviously be a discussion for the board to decide if that is how they desire the money to be spent. There are different ranges of no cost, low cost, and then upward and onward that we can dive into as we

look at options. Some of the lower costs could be social media, which was my first recommendation and step to do a big push. To answer your point about advertising to your local community, we will have to get costs and see if the board approves that. Lastly, for an outline for everyone, that is simple to do and I will get on that and give everyone a couple of talking points per project.

Chairman Miles thanked Melissa and thanked Commissioner Stubbs for bringing up these points. Seven County Infrastructure Coalition is unique and there is not another body in the State of Utah, like Seven County, oftentimes we get compared to an Association of Governments. We are different and I think one of the challenges that we have faced is people comparing us to them. We need to continue to emphasize this just so that they understand the difference between what we are trying to accomplish and how we accomplish it.

Chairman Miles stated that he thinks it is a great idea to emphasize the Infrastructure Coalition name more than adding Seven County. Something to always keep in mind is if we do need to make a name change and drop the number, it would be nice to add a county or two and do that naturally. A lot of us are in meetings and it is conference season, so as we have conversations, just emphasize the work that the Infrastructure Coalition is doing.

Chairman Miles would be happy to have the conversation in conjunction with Melissa's guidance on branding and for possible legal name change to something that is more differentiating. As we have more successes, we may get more tied to the existing name of Seven County.

Commissioner Lytle stated that our retreat is usually in April or May and if we give this some thought and then boil it down during that period, it seems like it would make sense if we talk about the terms of the branding, talking points, name changes, and a more in depth agenda.

Chairman Miles thanked Ms. Cano for her update, the board for the ideas and comments and asked if there were any questions from the board. Seeing none, Chairman Miles moved on to the next agenda item.

8. Presentation, Approval and Adoption of Monthly Expenses (Smuin, Rich & Marsing)

Chairman Miles turned the time over to Doug Rasmussen for the presentation, approval and adoption of monthly expenses. Mr. Rasmussen presented the financial information and requested payment approval today. He went on to request payment approval amounting to $90,880.25. If there is any discussion or review of any items included in the payment request today, he is happy to entertain or discuss those individual line items.

SEVEN COUNTY INFRASTRUCTURE COALITION PAYMENT APPROVAL
October 9, 2025 at 10:00 am
Carbon County Commission Chambers
751 East 100 North
Price, UT 84501

Expenses Previously Approved by Board :

Vendor	Check #	Invoice #	Amount	Description	Funding Source
Keith Heaton - Payroll	Direct Deposit	10/27/25-12/31/25	41,602.87	Payroll/Administration	General Grant

Checks Currently Being Approved:

Vendor		Invoice #	Amount	Description	Funding Source
Smuin, Rich & Marsing	3256	53372	5,591.00	Consulting Per Contract	General Grant
Keith Heaton	3257	41	1,000.95	Director's Travel and Admin Expenses	General Grant
Stacey Herpel	ACH	0925	1,232.00	Contract Labor	General Grant
Public Employees Health Program	3258	630529	1,760.10	Insurance Premiums - October	General Grant
Health Equity	3259	hdaqcw8	2.10	HSA Administration Fees - October	General Grant
Utah Office of Energy Development	3260	OED2601	10,000.00	Western States & Tribal Nations Mbrnshp.	General Grant
Jones & DeMille	3261	0138925	4,275.00	Program Management and Engineering	General Grant
Jones & DeMille	3261	0138938	6,000.00	Program Management and Engineering - Jensen Unit Pump Station Planning	General Grant
Jones & DeMille	3261	0138942	4,565.00	Program Management and Engineering - Ashley Valley Railway	General Grant
Kunz PC	3262	328	6,571.60	General - Legal Service	General Grant
Kunz PC	3263	329	2,175.00	Uinta Rail Line - Legal Service	Uinta Basin Railway Project Grant -STB Regulatory and Other Legal Services - Phase 2
Venable LLP (1/2 Invoice)	3264	2859092	10,000.00	Uinta Rail Line - Litigation Challenges to STB Decision	Uinta Basin Railway Project Grant -STB Regulatory and Other Legal Services - Phase 2
Stratton Law Firm PLLC	3265	154	8,557.50	Uinta Rail Line - Legal Services - PAB	Uinta Basin Railway Project Grant -STB Regulatory and Other Legal Services - Phase 2
Jones & DeMille	3266	0138940	13,100.00	Uinta Rail Line - Engineering	Uinta Basin Railway Project Grant - Program Management Services - Phase 2
Jones & DeMille	3266	0138940	13,300.00	Uinta Rail Line - Engineering	Uinta Basin Railway Project Grant - Strategic Communications - Phase 2
Kunz PC	3267	330	250.00	Greendale Resort Planning - Legal Services	Daggett County
Jones & DeMille	3268	0138939	2,500.00	Greendale Resort Planning - Engineering	Daggett County
Total Payment Approval			**$ 90,880.25**		

Motion to approve expenses for August in the amount of $90,880.25 was made by Commissioner Jensen seconded by Commissioner Norton.

Chairman Miles called for the vote. **The motion passed unanimously.**

Mr. Rasmussen then reviewed the balance sheet which was completed by September 30, 2025. It shows the total assets and liabilities of the Coalition with the second page showing profit and loss statements for September. We also have included a profit/loss by class which shows the funding and expenditures by project. We have detailed information for activity that has happened through September by project as well. He then asked if there were any questions regarding the financial information.

Motion to approve the financial report for September was made by Commissioner Worwood seconded by Commissioner Haddock.

Chairman Miles called for the vote. **The motion passed unanimously.**

Mr. Rasmussen stated for information purposes only, then reviewed the project sheet. This does not require any approval from the Coalition. He stated that this concluded the financial update to the Coalition.

Mr. Rasmussen stated that it is required after the end of every quarter that you receive a general ledger detail, which comprises all for the accounts of the coalition and activity that has transpired for the last quarter, which is July, August, and September. This is for your review and information, but it is a requirement that you have this so that you can look at the detailed information.

Chairman Miles thanked Mr. Rasmussen and Smuin, Rich & Marsing for their work efforts and moved to the closed session.

9. Motion for closed (executive) session pursuant to 52-4-205 (Litigation, personnel, real estate acquisition, &/or character/professional competency). (Greg Miles)

Chairman Miles then requested a motion for a closed session.

Motion to move into closed session for litigation was made by Commissioner Haddock seconded by Commissioner Worwood.

Chairman Miles called for a roll call vote to move into closed session. Motion passed; closed session began at 11:05 AM.

SEVEN COUNTY INFRASTRUCTURE COALITION VOTING

Carbon Board Member	Yea _X__	No ___
Daggett Board Member	Yea _X__	No ___
Duchesne Board Member	Yea _X_	No ___
Emery Board Member	Yea _X_	No ___
San Juan Board Member	Yea _X_	No ___
Sevier Board Member	Yea _X_	No ___
Uintah Board Member	Yea _X_	No ___

Chairman Miles requested a motion to move back into open session and exit the closed session.

Motion to move out of closed session was made by Commissioner Lytle with a second by Commissioner Worwood.

Chairman Miles called for a roll call vote with motion passing at 12:08 PM.

SEVEN COUNTY INFRASTRUCTURE COALITION VOTING:

Carbon Board Member	Yea _X_	No ___
Daggett Board Member	Yea _X_	No ___
Duchesne Board Member	Yea _X_	No ___
Emery Board Member	Yea _X_	No ___
San Juan Board Member	Yea _X_	No ___
Sevier Board Member	Yea _X_	No ___
Uintah Board Member	Yea _X_	No ___

10. Motion to Adjourn (Greg Miles)

A motion to adjourn was made by Commissioner Lytle at 12:09 PM.

A motion to approve the October 9, 2025 meeting minutes was made by Commissioner _____, seconded by Commissioner _____.

SEVEN COUNTY INFRASTRUCTURE COALITION VOTING:

Carbon Board Member	Yea _X_	No ___
Daggett Board Member	Yea _X_	No ___
Duchesne Board Member	Yea _X_	No ___
Emery Board Member	Yea _X_	No ___
San Juan Board Member	Yea _X_	No ___
Sevier Board Member	Yea _X_	No ___
Uintah Board Member	Yea _X_	No ___

_____

Co-Chair: Greg Miles

_____

Co-Chair: Jack Lytle

(COALITION SEAL)

ATTEST:

_____

Stacey Herpel

EXHIBIT 42

Build America Bureau Credit Assistance Pipeline
Information as of January 1, 2026

All information is subject to change due to applicant preferences, project and borrower circumstances, statutory and regulatory requirements, and other reasons.

Group	Applicant Name	Project Name	Project Location	Mode	Credit Assistance Program 1/	Type of Credit Assistance Sought 2/	Actual or Projected Loan Amount ($ million) 3/	Actual or Projected Eligible Project Costs ($ million) 4/	LOI or Application Received 5/	Application Complete 6/	Secretary's Notice of Approval or Disapproval	Financial Close	Actual or Projected Fiscal Year of Financial Close 7/	Actual or Projected Quarter of Financial Close 8/	Streamlined Application Process 9/
Closed Loans by financial close date															
Complete Applications by completion date															
	Boca Station, LLC	The Colony Boca Tri-Rail Station	FL	TOD	RRIF	Direct Loan	$ 129	$ 166	3/2/2023	12/11/2024	12/27/2024		2026	2	No
	Hampton Roads Transportation Accountability Commission	I-64 Hampton Roads Express Lanes Network Segments 1A, 1B, and 4A/B	VA	Highway	TIFIA	Direct Loan	$ 310	$ 940	9/5/2024	12/5/2025			2026	2	No
	Total Complete Applications						**$ 439**	**$ 1,106**							
Complete Letters of Interest by applicant name															
	Aberdeen, Carolina & Western Railway Company	ACWR Strategic Railway System Safety, State of Good Repair	NC	Rail	RRIF	Direct Loan	$ 49	$ 62	12/1/2021				2026	3	No
	Accordia Partners, LLC	Dorchester Bay City Phase I	MA	TOD	RRIF	Direct Loan	$ 470	$ 671	8/21/2023				2026	4	No
	Alabama Toll Road, Bridge and Tunnel Authority	I-10 Mobile River Bridge and Bayway	AL	Highway	TIFIA	Direct Loan	$ 1,788	$ 4,056	7/26/2024				2026	3	No
	Chicago Transit Authority	Red and Purple Modernization (RMP Phase 1)	IL	Transit	TIFIA	Direct Loan	$ 622	$ 2,135	3/13/2019				2026	3	No
	City and County of Denver	The Equestrian Center and Hotel Project at the National Western Center	CO	TOD	RRIF	Direct Loan	$ 431	$ 525	2/9/2024				2026	2	No
	City of Kansas City, Missouri	South Loop Project	MO	Highway	TIFIA	Direct Loan	$ 75	$ 217	5/16/2024				tbd		No
	City of McKinney / McKinney Community Development Corportation	Construct New Terminal	TX	Airport	TIFIA	Direct Loan	$ 30	$ 60	10/11/2024				2026	2	No
	Commuter Rail Division of the Regional Transportation Authority	Metra Bridge Improvement Program Phase 1	IL	Transit	RRIF	Direct Loan	$ 230	$ 481	3/7/2025				2026	2	No
	County Line Rail Fund I, LP	County Line Rail Projects	TX	Rail	RRIF	Direct Loan	$ 498	$ 663	6/20/2024				2026	3	No
	DesertXpress Enterprises, LLC	Brightline West High-Speed Intercity Passenger Rail	CA/NV	Rail	RRIF	Direct Loan	$ 6,000	$ 21,050	9/26/2025				2027	1	No
	Georgia Department of Transportation	I-285 East Express Lanes Project Phase 1	GA	Highway	TIFIA	Direct Loan	$ 2,500	$ 7,600	3/11/2025				2027	4	No
	Kentucky Public Transportation Infrastructure Authority	I-69 Ohio River Crossing Project Section 2	KY	Highway	TIFIA	Direct Loan	$ 350	$ 933	9/2/2025				2027	1	No
	Los Angeles County Metropolitan Transportation Authority	I-105 Express Lanes Project	CA	Highway	TIFIA	Direct Loan	$ 583	$ 1,766	5/25/2022				2026	2	No
	Massachusetts Bay Transportation Authority	Quincy Bus Facility Modernization	MA	Transit	TIFIA	Direct Loan	$ 211	$ 509	10/1/2025				2026	tbd	No
	Monterey Peninsula Airport District	Monterey Replacement Terminal Complex Project	CA	Airport	TIFIA	Direct Loan	$ 36	$ 94	10/2/2024				2026	3	No
	Municipality of Anchorage Alaska	Port of Alaska Modernization Program Phase I and Phase II	AK	Port	TIFIA	Direct Loan	$ 501	$ 1,502	2/1/2024				tbd		No
	New York City Economic Development Corporation	Hunts Point Terminal Produce Market Redevelopment	NY	Rail	RRIF	Direct Loan	$ 225	$ 650	7/10/2024				2026	2	No
	New York Metropolitan Transportation Authority	Second Avenue Subway Phase 2	NY	Transit	TIFIA	Direct Loan	$ 2,754	$ 7,700	3/1/2024				2026	tbd	No
	Northwest Arkansas Regional Airport Authority	XNA ConRAC	AR	Airport	TIFIA	Direct Loan	$ 37	$ 75	7/21/2025				2026	4	No
	Northwest Arkansas Regional Airport Authority	XNA West Terminal Expansion Project	AR	Airport	TIFIA	Direct Loan	$ 39	$ 99	7/28/2025				2026	4	No
	NTE Mobility Partners LLC	North Tarrant Expressway 1&2 Capacity Improvements	TX	Highway	TIFIA	Direct Loan	$ 212	$ 643	2/25/2025				2026	3	No
	Tennessee Department of Transportation	I-24 Southeast Choice Lanes	TN	Highway	TIFIA	Direct Loan	$ 1,100	$ 3,400	5/15/2025				2027	4	No
	Virginia Department of Transportation	I-81 Program – Rural Projects Group I	VA	Highway	TIFIA	Direct Loan	$ 46	$ 93	7/14/2025				tbd	tbd	No
	Virginia Department of Transportation	I-81 Program – Rural Projects Group II	VA	Highway	TIFIA	Direct Loan	$ 47	$ 96	7/14/2025				tbd	tbd	No
	Virginia Department of Transportation	I-81 Program – Rural Projects Group III	VA	Highway	TIFIA	Direct Loan	$ 49	$ 99	7/14/2025				tbd	tbd	No
	Virginia Department of Transportation	I-81 Program – Rural Projects Group IV	VA	Highway	TIFIA	Direct Loan	$ 48	$ 98	7/14/2025				tbd	tbd	No
	Virginia Department of Transportation	Long Bridge Project	VA	Rail	TIFIA	Direct Loan	$ 504	$ 2,697	10/10/2025				2027	1	No
	Total Complete Letters of Interest						**$ 19,435**	**$ 57,974**							
Draft Letters of Interest by applicant name															
	10 Dorrance, LLC	The Howard Building	RI	TOD	RRIF	Direct Loan	$ 20	$ 34	5/10/2024				2026	tbd	No
	10 Weybosset, LLC	The Amica Building	RI	TOD	RRIF	Direct Loan	$ 53	$ 65	5/10/2024				2026	tbd	No
	88 NOWA LLC	NOWA Hotel, Boston	MA	TOD	RRIF	Direct Loan	$ 22	$ 30	7/24/2024				tbd	tbd	No
	111 W Monroe, LLC	The Monroe Hotel and Residences	IL	TOD	RRIF	Direct Loan	$ 244	$ 338	3/5/2024				tbd	tbd	No
	251 Peter Smith Tenant, LP	The Standard at Southside Phase I	TX	TOD	RRIF	Direct Loan	$ 78	$ 104	6/13/2024				tbd	tbd	No
	Atlanta Development Authority d/b/a Invest Atlanta	Two Peachtree	GA	TOD	TIFIA	Direct Loan	$ 197	$ 403	4/29/2024				2026	tbd	No
	Bear Development, LLC	Iron District MKE Stadium	WI	TOD	RRIF	Direct Loan	$ 35	$ 99	3/15/2024				2026	tbd	No
	Bill and Hillary Clinton National Airport	Arrivals Hall and Terminal Commons	AR	Airport	TIFIA	Direct Loan	$ 134	$ 300	9/12/2025				tbd	tbd	No

Build America Bureau Credit Assistance Pipeline
Information as of January 1, 2026

All information is subject to change due to applicant preferences, project and borrower circumstances, statutory and regulatory requirements, and other reasons.

Group	Applicant Name	Project Name	Project Location	Mode	Credit Assistance Program 1/	Type of Credit Assistance Sought 2/	Actual or Projected Loan Amount ($ million) 3/	Actual or Projected Eligible Project Costs ($ million) 4/	LOI or Application Received 5/	Application Complete 6/	Secretary's Notice of Approval or Disapproval	Financial Close	Actual or Projected Fiscal Year of Financial Close 7/	Actual or Projected Quarter of Financial Close 8/	Streamlined Application Process 9/
	Bozeman Yellowstone International Airport	Terminal Expansion	MT	Airport	TIFIA	Direct Loan	$ 60	$ 191	8/28/2025				tbd	tbd	No
	Burlington International Airport	Snow Remove Equipment Building	VT	Airport	TIFIA	Direct Loan	$ 13	$ 27	9/25/2025				tbd	tbd	No
	Burlington International Airport	South Terminal Expansion	VT	Airport	TIFIA	Direct Loan	$ 37	$ 75	9/25/2025				tbd	tbd	No
	Brick Church 1B Developer LLC	The Crossings at Brick Church Phase 1B	NJ	TOD	RRIF	Direct Loan	$ 160	$ 265	10/19/2023				tbd	tbd	No
	Canal Edge, LLC	Chicago Keeps America Moving	IL	Rail	RRIF	Direct Loan	$ 383	$ 413	11/21/2025				2026	tbd	No
	Chehalis-Centralia Airport	Northeast and Southwest Airfield Development	WA	Airport	TIFIA	Direct Loan	$ 5	$ 11	9/19/2025				tbd	tbd	No
	City of Cleveland	North Coast Connector	OH	Highway	TIFIA	Direct Loan	$ 199	$ 447	4/21/2025				2026	tbd	No
	City of McAllen	MFE Terminal Renovation and Expansion Project	TX	Airport	TIFIA	Direct Loan	$ 69	$ 175	8/12/2025				2026	tbd	No
	City of Midland / Midland International Air & Space Port	MAF Terminal Expansion and Modernization Project	TX	Airport	TIFIA	Direct Loan	$ 23	$ 57	5/6/2025				2026	tbd	No
	City of Santa Barbara	SBA Terminal Improvement Project	CA	Airport	TIFIA	Direct Loan	$ 14	$ 40	8/12/2025				2026	tbd	No
	City of West Memphis	West Memphis South Loop Phase II	AR	Highway	TIFIA	Direct Loan	$ 7	$ 14	5/22/2025				2026	tbd	No
	Colorado Transportation Investment Office	I-70 Floyd Hill to Veterans Memorial Tunnels Improvements	CO	Highway	TIFIA	Direct Loan	$ 165	$ 835	5/16/2023				tbd	tbd	No
	Colorado Transportation Investment Office	Modernizing Rail on the Front Range	CO	Rail	RRIF	Direct Loan	$ 94	$ 94	8/5/2024				tbd	tbd	No
	Commodore Owner LLC	175 Park Avenue	NY	TOD	RRIF	Direct Loan	$ 4,840	$ 6,500	4/5/2024				2026	tbd	No
	Coos Bay Rail Line	Pacific Coast Intermodal Port	OR	Port	RRIF	Direct Loan	$ 1,700	$ 3,000	11/15/2023				2028	tbd	No
	Dallas Love Field Airport	Airfield Maintenance Facility and General Use Building	TX	Airport	TIFIA	Direct Loan	$ 40	$ 82	9/26/2025				tbd	tbd	No
	Dallas Love Field Airport	Terminal Concourse and Apron	TX	Airport	TIFIA	Direct Loan	$ 89	$ 258	9/26/2025				tbd	tbd	No
	Dallas Love Field Airport	Terminal Headhouse	TX	Airport	TIFIA	Direct Loan	$ 328	$ 690	9/26/2025				tbd	tbd	No
	Delaware Department of Transportation	DelDOT's Rural Projects	DE	Highway	TIFIA	Direct Loan	$ 183	$ 374	5/13/2024				2026	tbd	No
	Florence Regional Airport	Terminal Rehabilitation	SC	Airport	TIFIA	Direct Loan	$ 13	$ 38	9/12/2025				tbd	tbd	No
	Grand Canyon West Airport	New Terminal Building	AZ	Airport	TIFIA	Direct Loan	$ 16	$ 50	9/15/2025				tbd	tbd	No
	Grand Junction Regional Airport	Terminal Expansion	CO	Airport	TIFIA	Direct Loan	$ 18	$ 41	9/25/2025				tbd	tbd	No
	Greater Orlando Aviation Authority	Orlando CONRAC	FL	Airport	RRIF	Direct Loan	$ 900	$ 1,435	1/10/2025				2026	tbd	No
	Griffin-Spalding County Airport	Replacement Airport	GA	Airport	TIFIA	Direct Loan	$ 48	$ 99	9/9/2025				tbd	tbd	No
	Haymarket SL, LP	Haymarket Senior Living	NE	TOD	RRIF	Direct Loan	$ 95	$ 126	1/23/2024				tbd	tbd	No
	High Rock Westminster Street, LLC	111 Westminster Street	RI	TOD	RRIF	Direct Loan	$ 236	$ 318	5/22/2024				tbd	tbd	No
	High Valley Transit District	Campus Construction Project	UT	Transit	TIFIA	Direct Loan	$ 20	$ 45	7/31/2024				tbd	tbd	No
	Hood River White Salmon Bridge Authority	Hood River White Salmon Bridge Replacement	OR	Highway	TIFIA	Direct Loan	$ 105	$ 575	6/10/2024				tbd	tbd	No
	Islip Long Island MacArthur Airport	Terminal Rail Integration	NY	Airport	TIFIA	Direct Loan	$ 392	$ 1,000	9/25/2025				tbd	tbd	No
	Jackson Hole Airport	Aviation Safety Facility	WY	Airport	TIFIA	Direct Loan	$ 35	$ 98	9/22/2025				tbd	tbd	No
	Jackson-Medgar Wiley Evers International Airport	Terminal Renovation/Expansion	MS	Airport	TIFIA	Direct Loan	$ 249	$ 509	9/17/2025				tbd	tbd	No
	JFK NTO LLC	JFK NTO Phase B1 Project	NY	Airport	TIFIA	Direct Loan	$ 666	$ 1,700	9/8/2025				2026	tbd	No
	Joint Venture - Flagborough, LLC and Vineyard City	Vineyard Station Downtown Block 1	UT	TOD	TIFIA and RRIF	Direct Loan	$ 600	$ 850	4/17/2023				tbd	tbd	No
	Lakeland Linder International Airport	Terminal Area Development	FL	Airport	TIFIA	Direct Loan	$ 179	$ 600	9/25/2025				tbd	tbd	No
	Lakeland Linder International Airport	South Parallel Runway	FL	Airport	TIFIA	Direct Loan	$ 98	$ 200	9/25/2025				tbd	tbd	No
	Lansing Capital Region International Airport	Terminal Improvements	MI	Airport	TIFIA	Direct Loan	$ 114	$ 276	9/17/2025				tbd	tbd	No
	Los Angeles County Metropolitan Transportation Authority	Metro Strategic Investments for 2028 Olympics and Paralympics Games	CA	Transit	TIFIA	Direct Loan	$ 392	$ 800	11/20/2024				2026	tbd	No
	Madera County	Madera 41 South Expressway	CA	Highway	TIFIA	Direct Loan	$ 48	$ 97	10/15/2025				2026	tbd	No
	Medford Rogue Valley International Airport	Terminal Expansion	OR	Airport	TIFIA	Direct Loan	$ 44	$ 116	9/16/2025				tbd	tbd	No
	Multnomah County	Earthquake Ready Burnside Bridge	OR	Highway	TIFIA	Direct Loan	$ 347	$ 1,054	7/1/2024				tbd	tbd	No
	New Bedford Regional Airport	Airport Terminal Replacement	MA	Airport	TIFIA	Direct Loan	$ 20	$ 40	9/26/2025				tbd	tbd	No
	Northwest Arkansas Regional Airport Authority	XNA ConRAC	AR	Airport	TIFIA	Direct Loan	$ 37	$ 75	7/21/2025				2026	tbd	No
	Northwest Arkansas Regional Airport Authority	XNA West Terminal Expansion Project	AR	Airport	TIFIA	Direct Loan	$ 39	$ 99	7/28/2025				2026	tbd	No
	Northwest Florida Beaches International Airport	North Terminal Expansion	FL	Airport	TIFIA	Direct Loan	$ 52	$ 119	9/11/2025				tbd	tbd	No
	Northwest Regional Airport Authority	TVC Terminal Addition Concourse B Project	MI	Airport	TIFIA	Direct Loan	$ 30	$ 75	8/1/2025				2026	tbd	No
	Old Town Lewisville Tenant I, LP	The Standard at Old Town Phase I	TX	TOD	RRIF	Direct Loan	$ 73	$ 106	4/23/2024				tbd	tbd	No

Build America Bureau Credit Assistance Pipeline
Information as of January 1, 2026

All information is subject to change due to applicant preferences, project and borrower circumstances, statutory and regulatory requirements, and other reasons.

Group	Applicant Name	Project Name	Project Location	Mode	Credit Assistance Program 1/	Type of Credit Assistance Sought 2/	Actual or Projected Loan Amount ($ million) 3/	Actual or Projected Eligible Project Costs ($ million) 4/	LOI or Application Received 5/	Application Complete 6/	Secretary's Notice of Approval or Disapproval	Financial Close	Actual or Projected Fiscal Year of Financial Close 7/	Actual or Projected Quarter of Financial Close 8/	Streamlined Application Process 9/
	Pittsburgh Regional Transit	Light Rail Vehicle Replacement Program	PA	Transit	TIFIA	Direct Loan	$ 368	$ 754	6/23/2025				2026	tbd	No
	Premier Project Management LLC	Renaissance Tower Adaptive Re-Use	TX	TOD	RRIF	Direct Loan	$ 316	$ 535	4/25/2024				2025	tbd	No
	Relevant 12th Street Partners LLC	1200 S. Olive Street	CA	TOD	TIFIA	Direct Loan	$ 65	$ 164	3/5/2024				2026	tbd	No
	Relevant Olive Partners LLC	845 S. Olive Street	CA	TOD	TIFIA	Direct Loan	$ 61	$ 141	3/5/2024				2026	tbd	No
	Renewing Management, Inc	Singing Sands Suites	IN	TOD	TIFIA	Direct Loan	$ 37	$ 75	2/22/2024				tbd	tbd	No
	Renewing Management, Inc	Uptown Arts District Residences	IN	TOD	TIFIA	Direct Loan	$ 48	$ 97	3/12/2024				2026	tbd	No
	Rose Community Development Company, LLC	South Orange Redevelopment	NJ	TOD	RRIF	Direct Loan	$ 77	$ 125	5/10/2024				2026	tbd	No
	St. George Regional Airport	Terminal Expansion	UT	Airport	TIFIA	Direct Loan	$ 40	$ 96	9/26/2025				tbd	tbd	No
	Salt Lake City Corporation	The Grove	UT	TOD	TIFIA	Direct Loan	$ 82	$ 168	9/1/2024				2026	tbd	No
	Seattle-Tacoma International Airport	S Concourse	WA	Airport	TIFIA	Direct Loan	$ 454	$ 2,300	9/25/2025				tbd	tbd	No
	SkyCity VI Airports Company	STT Airport Modernization and Redevelopment Project	USVI	Airport	TIFIA	Direct Loan	$ 351	$ 1,300	9/5/2025				2026	tbd	No
	SkyCity VI Airports Company	STX Terminal Modernization and Redevelopment Project	USVI	Airport	TIFIA	Direct Loan	$ 39	$ 100	9/5/2025				2026	tbd	No
	Stadium View OZ, LLC	Stadium View Apartments	NC	TOD	RRIF	Direct Loan	$ 44	$ 59	12/20/2023				tbd	tbd	No
	The Michaels Organization	345 W. Ash Street	CA	TOD	RRIF	Direct Loan	$ 368	$ 490	3/11/2024				2027	tbd	No
	The Michaels Organization	1350 Front Street	CA	TOD	RRIF	Direct Loan	$ 300	$ 390	3/11/2024				2027	tbd	No
	Uinta Basin Railway Holdings, LLC	Uinta Basin Railway	UT	Rail	RRIF	Direct Loan	$ 2,800	$ 2,800	11/17/2025				2026	tbd	No
	Union Place Woodstock 1, LP	Union Place of Woodstock	IL	TOD	TIFIA	Direct Loan	$ 10	$ 26	12/28/2023				tbd	tbd	No
	UPSL Woodstock, LP	Union Place Senior Living of Woodstock	IL	TOD	TIFIA and RRIF	Direct Loan	$ 55	$ 73	12/20/2023				tbd	tbd	No
	Victoria Regional Airport	New Commercial Terminal Building	TX	Airport	TIFIA	Direct Loan	$ 11	$ 28	9/5/2025				tbd	tbd	No
	West Virginia International Yeager Airport	Airfield and Safety Improvements	WV	Airport	TIFIA	Direct Loan	$ 15	$ 342	9/19/2025				tbd	tbd	No
	West Virginia International Yeager Airport	CRW Terminal Expansion and Renovation Project	WV	Airport	TIFIA	Direct Loan	$ 25	$ 80	8/8/2025				tbd	tbd	No
	WS-Fenway-Twins Realty Venture LLC	55 Lansdowne	MA	TOD	RRIF	Direct Loan	$ 290	$ 386	9/23/2024				2026	tbd	No
	Yampa Valley Regional Airport	HDN West Terminal Expansion Project	CO	Airport	TIFIA	Direct Loan	$ 33	$ 74	3/25/2025				2026	tbd	No
	Total Draft Letters of Interest						**$ 19,943**	**$ 36,064**							

Notes

1/ TIFIA: Transportation Infrastructure Finance and Innovation Act; RRIF: Railroad Rehabilitiation and Investment Financing
2/ Direct loan, loan guarantee, or line of credit
3/ Subject to change until financial close
4/ Subject to change until project completion
5/ Date the Build America Bureau received the first LOI or Application
6/ Date the Build America Bureau confirms the customer has provided all necessary information for the application
7/ Subject to change until financial close
8/ Subject to change until financial close; tbd: to be determined
9/ Statute provides customers may request streamlined processing if they meet specified criteria; No: customer did not request

EXHIBIT 43

000001

SEVEN COUNTY INFRASTRUCTURE COALITION







PRE-FEASIBILITY STUDY OF A PROSPECTIVE RAILROAD CONNECTING THE UINTA BASIN TO THE NATIONAL RAIL NETWORK

A SUBMISSION TO:

SEVEN COUNTY INFRASTRUCTURE COALITION

SUBMITTED BY:

R.L. BANKS & ASSOCIATES, INC.

IN ASSOCIATION WITH:

HELIOS GROUP INC.

AUGUST 9, 2018

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ES.1 Executive Summary

Over the last decade the domestic oil industry has experienced an immense resurgence. Technological breakthroughs and advancements, combined with the repeal of the Federal ban on oil exports in 2015, have resulted in record domestic oil production. According to the US Energy Information Administration, since surpassing the previous monthly production record in November 2017, domestic oil production has continued to increase as of June 2018 to 10.9 million barrels per day (bpd), with many experts expecting that number to surpass 11 million bpd by late 2019. Most signs suggest that this trend is poised to continue. According to the International Energy Agency, worldwide demand for oil also will continue to grow over the next five years and the United States will supply most of the production to answer that growing demand.

While this significant growth has led to widespread exploration and development in select, domestic oil reserves, most notably in the Permian Basin, the Eagle Ford Group and the Bakken Formation, there still exists the need to support expanded production. One such example is the Uinta Basin. Despite substantial oil resources – estimated to be between 50-321 billion barrels – the geographically isolated Uinta Basin currently produces less than 90,000 bpd, the vast majority of which are transported to local refineries in Salt Lake City by truck at relatively high cost, resulting in major road congestion, safety issues, low efficiency and concerns that the production volumes are bumping up against these refineries' capacity to refine the oil.

Recognizing the intrinsic economic benefits of shipping large volumes of bulk commodities long distances, the Seven County Infrastructure Coalition (SCIC) contracted with a team led by R.L. Banks & Associates, Inc. (RLBA), to perform a pre-feasibility study examining the economic and operational feasibility of constructing and operating a railroad which would connect the Uinta Basin via one of three alignments with the national railroad network at one of two junctions in Colorado, as detailed later. This report is the culmination of that effort.

ES.2 Overview of Assignment

To better understand the transportation options available to Uinta Basin oil producers and other potential users of the prospective railroad, RLBA was asked to address several issues, including:

1. Determine commodities, volumes and destinations which could be expected to be shipped into or out of the Uinta Basin by rail if a rail transportation option existed;

2. Determine the cost to transport commodities between the Uinta Basin and a connection with the national rail system, given the results of the previous task, assuming the construction of the prospective railroad built on one of three previously identified rail alignments:

    - Myton/Leland Bench Area, UT - Rifle, CO, via Meeker Area;
    - Myton/Leland Bench Area, UT - Rifle, CO, via Piceance Creek and
    - Myton/Leland Bench Area, UT - Craig, CO.

3. Compare the rail transportation cost developed in the previous task to the cost of alternative transportation options to a connection with the national rail system, including:

    - Trucking between the Myton/Leland Bench Area and a rail transload facility at Price, UT, and
    - Pipelining between the Myton/Leland Bench Area and a rail transload facility at Price, UT;

4. Compare the cost to transport crude oil between the Uinta Basin and Salt Lake City area refineries via the five (three potential rail alignments, trucking/transloading and pipelining/transloading), alternative transportation options previously identified and trucking directly from the Myton/Leland Bench Area;

5. Determine the cost to transport commodities between the Uinta Basin and distant, national markets reached on the national rail system via the three, identified connections (Rifle, CO, Craig, CO and Price, UT) and

6. Offer recommendations based on the conclusions reached through the performance of the above-described tasks.

In the following sections this Executive Summary provides a synopsis of the methodologies, findings and conclusions regarding these tasks. Additional explanation and analysis is provided in the accompanying Final Report and supporting documentation.

ES.3 Conclusions Regarding Volume of Commodities Originating and Terminating in the Uinta Basin

To serve the needs of this study, RLBA developed forecasts of the number of carloads it believes are reasonable to assume would be carried by the prospective railroad during the period 2022 through 2044. To produce these forecasts, RLBA conducted multiple, extensive interviews with Uinta Basin producers/prospective rail shippers and receivers, prospective end users of Uinta Basin commodities, impacted railroads and other stakeholders. To best define the potential volumes, RLBA developed "Lower" and "Higher" forecasts in connection with crude oil and seven other commodities it believes might be hauled on that railroad. These forecasts yielded the following results.

Table ES-1
Estimated Annual Carloads Originating/Terminating in Uinta Basin, 2022-2044

	Crude Oil		Other Outbound		All Inbound		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	7,485	65,586	13,377	2,400	20,767	27,767	**41,629**	**95,753**
2023	22,456	109,785	13,377	2,400	24,863	49,223	**60,696**	**161,408**
2024	51,685	153,984	13,377	2,400	28,957	68,600	**94,018**	**224,984**
2025	78,787	157,064	9,955	2,400	33,053	69,972	**121,795**	**229,436**
2026	82,695	160,205	9,955	16,783	35,100	71,371	**127,750**	**248,360**
2027	83,522	163,409	9,955	16,783	35,451	72,799	**128,928**	**252,991**
2028	84,357	166,678	9,955	16,846	35,806	74,255	**130,118**	**257,778**
2029	85,201	170,011	9,955	24,037	36,164	75,740	**131,319**	**269,788**
2030	86,053	173,411	9,955	31,166	36,525	77,255	**132,533**	**281,832**
2031	86,914	176,880	9,955	31,166	36,890	78,800	**133,759**	**286,845**
2032	87,783	180,417	9,955	31,166	37,259	80,376	**134,997**	**291,959**
2033	88,661	184,026	9,955	31,166	37,632	81,983	**136,247**	**297,175**
2034 +	89,547	187,706	9,955	31,166	38,008	83,623	**137,510**	**302,495**

Higher "Other Outbound" carload volumes in the 2022 Lower forecast are due to the prospective Leland Bench Uintah Advantage refinery which, if built and operated, would result in fewer Crude Oil and Total carloads moving over the subject railroad (please see section 2.9).

The carloads in the Higher forecast reflect assumptions made by RLBA consistent with a theme that decisions would be made which would result in actions that would be favorable to the prospective railroad's viability: the primary assumption made is that market conditions will enable and motivate Uinta Basin oil producers to extract no less than 350,000 bpd (roughly 210,000 rail carloads per year) on a consistent basis. The carloads in the Lower forecast reflect a more conservative adoption of the prospective railroad. Both forecasts reflect a 'ramp up' period in their early years, driven by gradually increased production of crude oil in the Uinta Basin and an assumed greater acceptance of the Uinta Basin's crudes at various refineries, primarily located in Gulf Coast states.

ES.4 Conclusions Regarding the Viability of a New Railroad along the Three, Proposed Alignments in Light of the Forecasted Volumes Originating and Terminating in the Uinta Basin

Transportation costs into and out of the Uinta Basin consist of two components: 1) the cost to transport commodities from the Uinta Basin to a connection with the national rail network or in the opposite direction, a component which would be addressed by the construction of the proposed railroad and 2) the cost to transport commodities from said connection with the national rail network to a final destination via the Class One railroad(s) or in the opposite direction, providing the connection to the national rail network.

To determine the first component, the cost to transport commodities between the Uinta Basin and the national rail network, RLBA determined the break-even rate – or the lowest rate which the prospective railroad could charge prospective Uinta Basin rail shippers and still not operate at a loss – in connection

with each of the three potential rail alignments. Specifically, RLBA: 1) developed an operating and maintenance plan appropriate to host the types and volumes of commodities identified by RLBA between the Myton/Leland Bench Area, UT, and the national rail network connection with either UP and/or BNSF at Rifle, CO, or Craig, CO, depending on the specific alignment; 2) employed an updated, initial capital cost required to build each route developed in previous studies, provided by Jones & DeMille Engineering, Inc.; 3) applied real world costing data to said operating and maintenance plans, and 4) determined what rate prospective Uinta Basin rail shippers would be charged to make the prospective railroad on each of the alignments viable.

The three alignments, collectively determined to be the most feasible out of over the 20 plus routes originally considered, included:

1. Myton/Leland Bench Area, UT - Rifle, CO, via Meeker Area, providing a connection to both Union Pacific (UP) and BNSF Railway (BNSF) via a 183.31-mile route (including 152.97 new-build miles[1]), operating through predominately rolling hills and mountainous terrain;

2. Myton/Leland Bench Area, UT - Rifle, CO, via Piceance Creek, providing a connection to both UP and BNSF via a 185.13-mile route (including 154.80 new-build miles), operating through predominately rolling hills and mountainous terrain and

3. Myton/Leland Bench Area, UT - Craig, CO, providing a connection only to UP via a 157.27-mile route (including 126.93 new-build miles), operating through predominately rolling hills and flat terrain.

The application of the above-described methodologies yielded the results seen in table ES-2 regarding the Higher and Lower forecast volumes, respectively.

RLBA's results indicated that using the potential rail alignment to Craig would provide the lowest rates to shippers on the prospective railroad between the Myton/Leland Bench Area and a connection with the national rail network (in this case, at Craig, CO, with UP). It is important to note that this assessment does not consider or account for the cost which would be incurred by prospective Uinta Basin rail shippers to pay UP to transport commodities to and from Craig on the national rail system; it is simply the cost prospective shippers could expect to pay the prospective railroad to reach the national rail system from the Myton/Leland Bench Area.

Because the prospective railroad was assumed to handle the same amount of traffic regardless of alignment (all traffic in and out of the Uinta Basin area was assumed to have been loaded and off loaded in the Myton or Leland Bench Area), the cost savings associated with the Craig rail alignment can be attributed to: 1) the lower initial capital costs to construct the line, largely due to the shorter mileage, and 2) lower operating and maintenance costs on that route, again, largely due to its the shorter mileage and more favorable physical characteristics.

1 All three alignments assume the integration of the existing Deseret Power Railroad.

Table ES-2
Rail Transportation Break-Even Rate per Carload and Barrel;
Myton/Leland Bench Area - Connection with the National Rail Network, Lower and Higher Volume Forecast, 2022-2044

Lower

	Rifle Via Meeker Area				Rifle Via Piceance Creek				Craig			
			Break Even Rate				Break Even Rate				Break Even Rate	
Year	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel
2022	$ 151,679,388	41,629	$ 3,643.57	$ 5.69	$ 154,169,135	41,629	$ 3,703.38	$ 5.79	$ 118,621,360	41,629	$ 2,849.46	$ 4.45
2023	$ 159,013,061	60,696	$ 2,619.84	$ 4.09	$ 161,620,207	60,696	$ 2,662.80	$ 4.16	$ 123,889,460	60,696	$ 2,041.16	$ 3.19
2024	$ 171,966,462	94,018	$ 1,829.08	$ 2.86	$ 174,778,590	94,018	$ 1,858.99	$ 2.90	$ 133,309,824	94,018	$ 1,417.92	$ 2.22
2025	$ 182,480,853	121,795	$ 1,498.26	$ 2.34	$ 185,463,673	121,795	$ 1,522.75	$ 2.38	$ 141,283,208	121,795	$ 1,160.01	$ 1.81
2026	$ 184,375,678	127,750	$ 1,443.25	$ 2.26	$ 187,395,214	127,750	$ 1,466.89	$ 2.29	$ 142,671,970	127,750	$ 1,116.81	$ 1.75
2027	$ 184,868,719	128,928	$ 1,433.89	$ 2.24	$ 187,895,515	128,928	$ 1,457.37	$ 2.28	$ 143,065,215	128,928	$ 1,109.65	$ 1.73
2028	$ 185,368,160	130,118	$ 1,424.62	$ 2.23	$ 188,402,288	130,118	$ 1,447.94	$ 2.26	$ 143,463,864	130,118	$ 1,102.57	$ 1.72
2029	$ 187,461,737	131,319	$ 1,427.53	$ 2.23	$ 190,511,785	131,319	$ 1,450.75	$ 2.27	$ 145,672,729	131,319	$ 1,109.30	$ 1.73
2030	$ 187,974,258	132,533	$ 1,418.32	$ 2.22	$ 191,031,785	132,533	$ 1,441.39	$ 2.25	$ 146,082,439	132,533	$ 1,102.23	$ 1.72
2031	$ 188,940,214	133,759	$ 1,412.54	$ 2.21	$ 192,005,295	133,759	$ 1,435.46	$ 2.24	$ 146,497,809	133,759	$ 1,095.24	$ 1.71
2032 +	$ 191,401,532	134,997	$ 1,417.82	$ 2.22	$ 194,515,281	134,997	$ 1,440.89	$ 2.25	$ 148,489,587	134,997	$ 1,099.95	$ 1.72
Average	**$ 185,701,558**	**124,351**	**$ 1,493.36**	**$ 2.33**	**$ 188,727,429**	**124,351**	**$ 1,517.69**	**$ 2.37**	**$ 144,100,418**	**124,351**	**$ 1,158.82**	**$ 1.81**

Higher

	Rifle Via Meeker Area				Rifle Via Piceance Creek				Craig			
			Break Even Rate				Break Even Rate				Break Even Rate	
Year	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel
2022	$ 179,203,020	95,753	$ 1,871.52	$ 2.92	$ 182,427,321	95,753	$ 1,905.19	$ 2.98	$ 140,266,728	95,753	$ 1,464.89	$ 2.29
2023	$ 203,394,990	161,408	$ 1,260.13	$ 1.97	$ 207,311,438	161,408	$ 1,284.39	$ 2.01	$ 157,986,083	161,408	$ 978.80	$ 1.53
2024	$ 228,127,547	224,984	$ 1,013.97	$ 1.58	$ 232,714,058	224,984	$ 1,034.36	$ 1.62	$ 176,424,175	224,984	$ 784.16	$ 1.23
2025	$ 229,607,112	229,436	$ 1,000.75	$ 1.56	$ 234,240,544	229,436	$ 1,020.94	$ 1.60	$ 177,528,440	229,436	$ 773.76	$ 1.21
2026	$ 235,375,117	248,360	$ 947.72	$ 1.48	$ 240,207,777	248,360	$ 967.18	$ 1.51	$ 182,582,561	248,360	$ 735.15	$ 1.15
2027	$ 238,254,711	252,991	$ 941.75	$ 1.47	$ 243,136,187	252,991	$ 961.05	$ 1.50	$ 183,731,439	252,991	$ 726.24	$ 1.13
2028	$ 239,843,956	257,778	$ 930.43	$ 1.45	$ 244,775,225	257,778	$ 949.56	$ 1.48	$ 184,920,499	257,778	$ 717.36	$ 1.12
2029	$ 245,236,965	269,788	$ 909.00	$ 1.42	$ 250,303,222	269,788	$ 927.78	$ 1.45	$ 189,065,328	269,788	$ 700.79	$ 1.09
2030	$ 251,474,291	281,832	$ 892.28	$ 1.39	$ 256,668,037	281,832	$ 910.71	$ 1.42	$ 193,831,148	281,832	$ 687.75	$ 1.07
2031	$ 253,140,522	286,845	$ 882.50	$ 1.38	$ 258,387,108	286,845	$ 900.79	$ 1.41	$ 195,074,729	286,845	$ 680.07	$ 1.06
2032 +	$ 256,875,769	291,959	$ 879.83	$ 1.37	$ 262,217,289	291,959	$ 898.13	$ 1.40	$ 198,013,944	291,959	$ 678.23	$ 1.06
Average	**$ 245,835,291**	**267,656**	**$ 918.48**	**$ 1.44**	**$ 250,898,331**	**267,656**	**$ 937.39**	**$ 1.47**	**$ 189,732,382**	**267,656**	**$ 708.87**	**$ 1.11**

ES.5 Conclusions Regarding the Transportation Cost to Reach the National Rail Network across the Various Transportation Options Potentially Available in the Uinta Basin (Rail, Pipe and Truck)

To understand the full spectrum of transportation options potentially available to existing and prospective Uinta Basin shippers, RLBA compared the transportation rates of what were previously identified as the two most viable alternatives to the prospective railroad between the Myton/Leland Bench Area and a connection with the national rail network. These alternatives are:

1. Contracting a third party entity to truck crude oil to a rail transload facility at Price, UT, using rates developed by RLBA and

2. Constructing and operating a dedicated, crude oil pipeline to a rail transload facility at Price, UT, using rates developed by HDR, Inc. in previous studies.

This comparison yielded the following results.

Table ES-3
Alternative Transportation Rate Comparison per Barrel;
Myton/Leland Bench Area - Connection with the National Rail Network

	Rail						Truck	Pipeline
	Rifle via Meeker		Rifle Via Piceance		Craig			
Item	Lower	Higher	Lower	Higher	Lower	Higher	Cost	Cost
Rail Car Lease	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ -	$ -
Transport to National Network	$ 2.33	$ 1.44	$ 2.37	$ 1.47	$ 1.81	$ 1.11	$ 3.00	$ 1.40
Transload at National Network	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.50	$ 1.50
Total	**$ 2.50**	**$ 1.60**	**$ 2.54**	**$ 1.63**	**$ 1.98**	**$ 1.27**	**$ 4.50**	**$ 2.90**

RLBA's results indicated that in both the Higher and Lower forecasts, the prospective railroad, the UBRR, would provide the lowest transportation cost between the Myton/Leland Bench, UT area and a connection with the national rail network. These results were due to the fact that: 1) the high volumes of commodities estimated to ship via rail, including those other than crude oil, greatly amplify the superior economics of scale intrinsic to the rail mode, and 2) the additional cost of transloading or 'double handling' crude oil into railcars at the connection to the national rail network negatively impacts the competitiveness of non-rail transportation options. On the other hand, the rail mode offers economic development and other benefits to the Uinta Basin economy that are unlikely to be realized in the event a pipeline was constructed in the alternative. Specifically, the prospective railroad would be both more flexible (featuring the ability to transport multiple types of commodities in both directions and scalable (in that additional infrastructure could be added, as needed, at an economical cost), compared to a pipeline.

ES.6 Conclusions Regarding the Total Transportation Cost to Ship to National Markets

While important, determining the transportation cost between the Uinta Basin and the national rail network is only one of the two components of the true transportation cost into and out of the Uinta Basin. Once commodities have reached the national rail network, a Class One railroad – either UP or BNSF, depending on the junction location – must be engaged to perform final delivery. Because the Class Ones will handle Uinta commodities over the majority of the miles to/from distant markets, Class One rates likely will be the single largest cost component.

To determine the above-referenced Class One rates, RLBA estimated rates which prospective Uinta Basin rail shippers would have to pay to transport Uinta Basin commodities via UP and/or BNSF routings across the national rail system to eleven, target refineries identified as part of the study process. RLBA also estimated prospective rates on seven other commodities involving eleven potential destinations/ origins. Additionally, RLBA calculated and included the cost associated with leasing rail cars to transport Uinta Basin commodities across the UBRR and the national rail system.

The application of this methodology yielded the following results, amended here to show only results regarding crude oil.

Table ES-4
Rail Transportation and Equipment Lease Rates per Barrel;
Connection with the National Rail Network - National Markets

Oil Type			Union Pacific			BNSF Railway	
Destination		Customer	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
LA	Shreveport	Crude - Calumet	$ 7.49	$ 7.40	$ 8.34	$ 6.67	$ 7.50
MS	Pascagoula	Crude - Chevron	$ 9.21	$ 9.11	$ 10.05	$ 8.18	$ 9.01
LA	Baton Rouge	Crude - Exxon Mobil	$ 8.16	$ 8.07	$ 9.01	$ 7.79	$ 8.62
TX	Baytown	Crude - Exxon Mobil	$ 7.11	$ 7.02	$ 7.96	$ 6.25	$ 7.08
KY	Catlettsburg	Crude - Marathon	$ 8.86	$ 8.77	$ 10.09	$ 8.25	$ 9.28
LA	Garyville	Crude - Marathon	$ 9.51	$ 9.42	$ 10.36	$ 8.82	$ 9.65
TX	Galveston Bay	Crude - Marathon	$ 7.17	$ 7.08	$ 8.02	$ 6.28	$ 7.11
WA	Anacortes	Crude - Marathon	$ 8.21	$ 7.46	$ 6.58	$ 7.54	$ 6.76
TX	Port Arthur	Crude - Motiva	$ 7.37	$ 7.28	$ 8.22	$ 6.46	$ 7.29
LA	Norco	Crude - Shell	$ 9.43	$ 9.34	$ 10.28	$ 8.74	$ 9.57
LA	Convent	Crude - Shell	$ 9.58	$ 9.49	$ 10.43	$ 8.88	$ 9.71
TX	Deer Park	Crude - Shell / Pemex	$ 6.98	$ 6.82	$ 7.76	$ 6.58	$ 7.40
TX	Port Arthur	Crude - Valero	$ 7.37	$ 7.28	$ 8.22	$ 6.46	$ 7.29
OK	Cushing	Crude - Transload	$ 5.42	$ 5.33	$ 6.27	$ 4.78	$ 5.61
UT	North Salt Lake	Crude - Big West Oil	$ 2.97	$ 2.16	$ 1.15	$ 2.19	$ 1.15
UT	Salt Lake City	Crude - Shevron	$ 2.95	$ 2.14	$ 1.13	$ 2.17	$ 1.13
UT	Salt Lake City	Crude - Tesoro	$ 2.95	$ 2.14	$ 1.13	$ 2.17	$ 1.13
UT	Woods Cross	Crude - HollyFrontier	$ 2.98	$ 2.18	$ 1.16	$ 2.21	$ 1.17
UT	Salt Lake City	Shale - Enefit	$ 6.47	$ 5.11	$ 3.49	$ 4.70	$ 3.24
CA	Los Angeles	Shale - Enefit	$ 11.21	$ 9.93	$ 8.23	$ 11.31	$ 9.86
TX	Houston	Shale - Enefit	$ 10.85	$ 10.89	$ 11.90	$ 9.22	$ 10.18

Red emphasis indicates highest rate, green emphasis indicates lowest rate

RLBA's results indicated that the Class Ones' rates are greatly influenced by the length of haul between origins and destinations. The closer a candidate terminal is to each of the three potential connections to the national rail network, the lower the rates it would logically enjoy, generally because the haul lengths are shorter. In general, BNSF appears to be able to provide lower rates than UP to southeastern refineries, likely in part due to a shorter routing on BNSF, suggesting that the net benefits for prospective Uinta Base rail shippers of building the prospective railroad along one of the more expensive Rifle alignments may outweigh the lower construction and operating cost of the Craig option.

To offer a final opinion regarding what the total transportation cost which prospective Uinta Basin rail shippers might pay to ship via the prospective railroad between the Myton/Leland Bench Area and national markets, RLBA synthesized the following values, including:

1. The average annual break-even rate for each of three prospective rail alignments at both the Higher and Lower forecast volumes;
2. The estimated freight rate across the national system to the various identified destinations/originations and
3. The estimated equipment lease rates.

This comparison yielded the results shown on the next page, amended here to show only results regarding crude oil.

RLBA's results indicated that at the Higher forecast volume the Rifle via Meeker alignment, allowing for interchange with both UP and BNSF, offers prospective Uinta Basin rail shippers the lowest total rail transportation cost on all 33 identified shipping lanes. RLBA's results also indicate that at the Lower forecast volume the Rifle via Meeker alignment, allowing interchange with both UP and BNSF, offers prospective Uinta Basin rail shippers the lowest total rail transportation cost on 30 of the 33 identified shipping lanes (90%).

ES.7 Conclusions Regarding the Transportation Cost to Reach Salt Lake City Refineries across the Various Transportation Options Out of the Uinta Basin

While the primary objective of this study was to determine transportation rates/costs to distant markets, the Salt Lake City markets are currently, and figure to remain under any expansion scenario, a major market for Uinta Basin crude oil. As such, RLBA compared the cost of the various transportation options previously identified against the real world cost paid today to transport Uinta Basin crude oil to Salt Lake City via contract trucking. To do so, RLBA: 1) applied the same methodology to determine the costs incurred to reach national markets; 2) considered real world contract trucking rates as reported in a previous study performed by HDR, Inc., and 3) considered costs regarding a dedicated, crude oil pipeline to a rail transloading facility at Price, UT, developed in a previous study performed by HDR, Inc.

This methodology produced the results seen on Table ES-6.

Table ES-5
Rail Transportation and Equipment Lease Rate per Barrel;
Myton/Leland Bench Area - National Market, Lower and Higher Volume Forecasts

Lower

	Destination	Customer	Union Pacific Rifle via Meeker	Union Pacific Rifle via Piceance	Craig	BNSF Railway Rifle via Meeker	BNSF Railway Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 9.90	$ 9.94	$ 9.47	$ 9.17	$ 9.21
MS	Pascagoula	Crude - Chevron	$ 11.62	$ 11.65	$ 11.19	$ 10.68	$ 10.72
LA	Baton Rouge	Crude - Exxon Mobil	$ 10.57	$ 10.61	$ 10.14	$ 10.29	$ 10.33
TX	Baytown	Crude - Exxon Mobil	$ 9.52	$ 9.56	$ 9.09	$ 8.75	$ 8.79
KY	Catlettsburg	Crude - Marathon	$ 11.27	$ 11.31	$ 10.84	$ 10.76	$ 10.79
LA	Garyville	Crude - Marathon	$ 11.92	$ 11.96	$ 11.49	$ 11.32	$ 11.36
TX	Galveston Bay	Crude - Marathon	$ 9.58	$ 9.62	$ 9.15	$ 8.78	$ 8.82
WA	Anacortes	Crude - Marathon	$ 9.96	$ 10.00	$ 10.19	$ 10.04	$ 10.08
TX	Port Arthur	Crude - Motiva	$ 9.78	$ 9.82	$ 9.35	$ 8.96	$ 9.00
LA	Norco	Crude - Shell	$ 11.84	$ 11.88	$ 11.42	$ 11.24	$ 11.28
LA	Convent	Crude - Shell	$ 11.99	$ 12.03	$ 11.56	$ 11.39	$ 11.43
TX	Deer Park	Crude - Shell / Pemex	$ 9.32	$ 9.36	$ 8.96	$ 9.08	$ 9.12
TX	Port Arthur	Crude - Valero	$ 9.78	$ 9.82	$ 9.35	$ 8.96	$ 9.00
OK	Cushing	Crude - Transload	$ 7.83	$ 7.87	$ 7.40	$ 7.28	$ 7.32
UT	North Salt Lake	Crude - Big West Oil	$ 4.67	$ 4.70	$ 4.95	$ 4.70	$ 4.74
UT	Salt Lake City	Crude - Chevron	$ 4.64	$ 4.68	$ 4.93	$ 4.67	$ 4.71
UT	Salt Lake City	Crude - Tesoro	$ 4.64	$ 4.68	$ 4.93	$ 4.67	$ 4.71
UT	Woods Cross	Crude - HollyFrontier	$ 4.68	$ 4.72	$ 4.97	$ 4.71	$ 4.75
UT	Salt Lake City	Shale - Enefit	$ 7.61	$ 7.65	$ 8.45	$ 7.21	$ 7.24
CA	Los Angeles	Shale - Enefit	$ 12.43	$ 12.47	$ 13.19	$ 13.81	$ 13.85
TX	Houston	Shale - Enefit	$ 13.39	$ 13.43	$ 12.83	$ 11.73	$ 11.77

Higher

	Destination	Customer	Union Pacific Rifle via Meeker	Union Pacific Rifle via Piceance	Craig	BNSF Railway Rifle via Meeker	BNSF Railway Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 9.01	$ 9.03	$ 8.77	$ 8.27	$ 8.30
MS	Pascagoula	Crude - Chevron	$ 10.72	$ 10.75	$ 10.48	$ 9.78	$ 9.81
LA	Baton Rouge	Crude - Exxon Mobil	$ 9.68	$ 9.70	$ 9.44	$ 9.39	$ 9.42
TX	Baytown	Crude - Exxon Mobil	$ 8.62	$ 8.65	$ 8.39	$ 7.86	$ 7.88
KY	Catlettsburg	Crude - Marathon	$ 10.37	$ 10.40	$ 10.14	$ 9.86	$ 9.89
LA	Garyville	Crude - Marathon	$ 11.02	$ 11.05	$ 10.79	$ 10.42	$ 10.45
TX	Galveston Bay	Crude - Marathon	$ 8.68	$ 8.71	$ 8.45	$ 7.89	$ 7.92
WA	Anacortes	Crude - Marathon	$ 9.07	$ 9.10	$ 9.48	$ 9.14	$ 9.17
TX	Port Arthur	Crude - Motiva	$ 8.88	$ 8.91	$ 8.65	$ 8.06	$ 8.09
LA	Norco	Crude - Shell	$ 10.95	$ 10.98	$ 10.71	$ 10.34	$ 10.37
LA	Convent	Crude - Shell	$ 11.09	$ 11.12	$ 10.86	$ 10.49	$ 10.52
TX	Deer Park	Crude - Shell / Pemex	$ 8.43	$ 8.45	$ 8.26	$ 8.19	$ 8.22
TX	Port Arthur	Crude - Valero	$ 8.88	$ 8.91	$ 8.65	$ 8.06	$ 8.09
OK	Cushing	Crude - Transload	$ 6.93	$ 6.96	$ 6.70	$ 6.38	$ 6.41
UT	North Salt Lake	Crude - Big West Oil	$ 3.77	$ 3.80	$ 4.25	$ 3.80	$ 3.83
UT	Salt Lake City	Crude - Chevron	$ 3.75	$ 3.78	$ 4.23	$ 3.77	$ 3.80
UT	Salt Lake City	Crude - Tesoro	$ 3.75	$ 3.78	$ 4.23	$ 3.77	$ 3.80
UT	Woods Cross	Crude - HollyFrontier	$ 3.78	$ 3.81	$ 4.26	$ 3.82	$ 3.85
UT	Salt Lake City	Shale - Enefit	$ 6.71	$ 6.74	$ 7.74	$ 6.31	$ 6.34
CA	Los Angeles	Shale - Enefit	$ 9.93	$ 11.56	$ 12.49	$ 12.91	$ 12.94
TX	Houston	Shale - Enefit	$ 10.89	$ 12.52	$ 12.13	$ 10.83	$ 10.86

Red emphasis indicates highest rate, green emphasis indicates lowest rate

Table ES-6
Alternative Transportation Rate Comparison per Barrl;
Myton/Leland Bench Area - Salt Lake City Markets

	Rail						Truck		Pipeline
	Rifle via Meeker		Rifle Via Piceance		Craig				
Item	Lower	Higher	Lower	Higher	Lower	Higher	Price	Salt Lake	Price
Rail Car Lease	$ 0.64	$ 0.64	$ 0.64	$ 0.64	$ 0.71	$ 0.71	$ 0.54	$ -	$ -
Transport to National Network	$ 2.33	$ 1.44	$ 2.37	$ 1.47	$ 1.81	$ 1.11	$ 3.00	$ -	$ -
Transload at National Network	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.50	$ -	$ -
Union Pacific to Salt Lake City	$ 1.68	$ 1.68	$ 1.68	$ 1.68	$ 2.42	$ 2.42	$ 0.77	$ -	$ -
BNSF Railway to Salt Lake City	$ 1.71	$ 1.71	$ 1.71	$ 1.71	$ -	$ -	$ 0.77	$ -	$ -
Truck to Salt Lake City (HDR)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5.75	$ -
Truck-Pipe-Rail-Pipe (HDR)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6.11
Transload at Salt Lake City	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ -	$ -
Total via UP	**$ 6.16**	**$ 5.26**	**$ 6.20**	**$ 5.29**	**$ 6.44**	**$ 5.74**	**$ 7.31**	**$ -**	**$ -**
Total via BNSF	**$ 6.19**	**$ 5.29**	**$ 6.23**	**$ 5.32**	**$ -**	**$ -**	**$ 7.32**	**$ -**	**$ -**
Best PossibleTotal	**$ 6.16**	**$ 5.26**	**$ 6.20**	**$ 5.29**	**$ 6.44**	**$ 5.74**	**$ 7.31**	**$ 5.75**	**$ 6.11**

RLBA's results indicated that at the Higher forecast volume estimates an all-rail routing assuming interchange with UP at Rifle, CO, provided the most competitive transportation cost. However, at the Lower forecast volume estimates the current practice of trucking directly to Salt Lake City offered the most competitive cost. Additionally, the estimated rate charged by UP to handle traffic from the most distant connection - the Craig, CO, interchange - negated any cost savings prospective Uinta Basin rail shippers would realize thanks to the lower construction, maintenance and operating costs associated with the Craig, CO, rail alignment. Not captured in RLBA's results is the cost to construct the required facilities to accept and handle railcars at Salt Lake City area refineries.

ES.8 Recommendations based on Conclusions

1. **Volumes** - To reiterate the importance and impact of the four challenges described earlier, the viability and competitiveness of the prospective railroad is directly related to the volumes of traffic which would be shipped over the line.

2. **Feasibility of the Proposed Railroad** - Assuming the forecasted volumes can be achieved, it appears that the proposed railroad can offer cost competitive transportation to prospective Uinta Basin rail shippers, as compared with the most practical identified transport alternatives. Beyond the immediate quantifiable monetary benefits, the proposed railroad also would offer more flexibility to transport into and out of the Uinta Basin secondary and tertiary commodities related to both crude oil extraction and other industries.

3. **Multiple Class One Connections** - The Class One rate estimation work conducted by RLBA suggests that the additional construction costs necessary to reach Rifle, CO, may be justified by the savings potentially realized by prospective Uinta Basin rail shippers due to the advantages of being served by two Class One carriers instead of being 'captive' to only one. To this point RLBA

estimates that BNSF Railway, the second Class One reached via a connection at Rifle, CO, in general, may offer lower rates to and from the distant locations which are markets for Uinta Basin commodities and sources of commodities consumed in the Uinta Basin. Furthermore, prospective Uinta Basin rail shippers might be able to leverage the two Class Ones against one another in negotiations to receive even more favorable rates than those estimated by RLBA. Similarly, shippers should be able to secure better service than would be the case if only one of those railroads provided service.

4. **Alignment Selection** - While the Craig rail alignment appears to be significantly less costly to both construct and operate than either Rifle alignment, the Craig alignment: 1) is generally farther from the markets for Uinta Basin commodities; 2) lacks a second Class One connection, and 3) is located at the end of relatively isolated UP branch line. As a result, the total rail transportation cost, the sum of the costs to reach the national rail network and then to ship over the national rail network, incurred by prospective Uinta Basin rail shippers would likely be higher using the Craig rail alignment, both to distant markets and Salt Lake City. As such, if the ultimate goal of constructing the prospective railroad is to advance the economic development of the Uinta Basin, it would appear as though the Rifle via Meeker Area rail alignment would be the most prudent selection.

5. **Salt Lake City** - The short haul length (by rail standards) to Salt Lake City makes an all-rail transportation option utilizing a combination of the prospective railroad and a Class One intrinsically less competitive, though potentially still feasible. If the prospective railroad can obtain the High forecast volumes, the economies of scale are such that rail may be the most cost competitive option. If said High forecast volumes cannot be obtained, the Salt Lake City market may not be competitive for rail. In either case, as regards the prospective railroad, RLBA would consider Salt Lake City to be a secondary market to more distant markets.

1.0 Introduction

Despite substantial known natural petroleum resources and record growth in the domestic oil industry, to date, oil production in the Uinta Basin region of northeastern Utah consistently remains substantially lower than that of similar, large oil plays across the United States – approximately 70,000 to 90,000 bpd. What's more, essentially all this production is transported almost entirely by truck to five small-to-midsize refineries located in the north Salt Lake City metro area. Despite significant national demand for the specific type of crude oil found in the Uinta Basin, producers in the Basin have been unable to find national markets willing to purchase their production at prices which would facilitate widespread economical oil extraction in the region.

Chief among the issues thwarting the penetration of Uinta Basin crude oil and other petroleum resources into national markets is the lack of sufficient transportation infrastructure to bring products to market. While a main line of the nation's largest railroad – Union Pacific – passes within 100 miles of the Uinta Basin, to date the rugged topography of the region has limited transportation options between the oil producers of the Uinta Basin and the national rail network to expensive, inefficient and publically burdensome trucks. These high costs have decreased significantly the profit margins Uinta Basin producers have realized on their products, often approaching a 17% discount. The aforementioned five Salt Lake City refineries - which currently constitute essentially the entire market for Uinta Basin crude oil – remain very aware of the constrained markets into which Uinta Basin producers can sell, manifesting that awareness by insisting on paying prices that represent a substantial discount to West Texas Intermediate ("WTI"), the primary onshore benchmark against which domestic U.S. oil prices are quoted.

As long as the transportation infrastructure into and out of the Uinta Basin remains status quo, discounted returns and constrained production capability can be expected to continue. As such, both public sector leaders and the managers of private sector oil production companies in the Uinta Basin are convinced of four things:

1. that Uinta Basin producers will remain both captive to the five refineries and perpetually captive to the discount that those refineries impose upon them unless and until something is done to significantly change the status quo;

2. that a significantly larger volume of oil is available and could be produced quickly if additional markets were available in which to sell Uinta Basin oil;

3. that there are a number of markets, both refineries and intermediate storage/blending locations, which would be receptive enough to the region's oil that not only would production in northeast Utah increase significantly, but those producers would be able to reduce significantly, if not eliminate, the discount to WTI (even in Salt Lake City) that is their fate so long as no alternatives exist by which to sell their oil; and

4. that the best option available to take advantage of the Uinta Basin's abundant oil and shale reserves is to construct a pipeline or railroad to connect the subject region with already-built transportation infrastructure ready to carry oil to distant markets.

In light of these revelations, it should not be surprising that public and private sector leaders in northeast Utah have spent the last several years examining the feasibility and economic viability of constructing and operating a pipeline to reach northeastern Utah. Indeed, a pipeline might well become the economic salvation sought by both public sector economic development leadership in northeast Utah and the oil producers on whom they hope to rely to achieve an improved economy in the region over the long term. That said, aside from its extremely high initial capital cost, the potential pipeline solution suffers from one major disadvantage, which is that a pipeline only can move one product in one direction at any one time. In contrast, a railroad could be used both to move oil and other commodities out of the region, and other commodities, significantly including materials to facilitate the drilling of oil and gas wells, into the region at the same time. Nor is a pipeline scalable in the sense that it can be expanded readily to handle more traffic.

Understanding the advantages inherent to railroads and disadvantages inherent to pipelines, the public sector, specifically the SCIC, in consultation with private sector producers, commissioned a team lead by R.L. Banks & Associates (RLBA), in association with Helios Group Inc., to conduct a pre-feasibility study to examine the potential viability of constructing a railroad on one of three potential alignments between the Uinta Basin and two different terminals, Rifle and Craig, Colorado. This report is the culmination of that effort.

1.1 Description of Assignment

To better understand the feasibility of the prospective railroad connecting the Uinta Basin with the national rail network, RLBA was asked to address several issues, including to:

1. Determine commodities, volumes and destinations which could be expected to be shipped into or out of the Uinta Basin by rail if a rail transportation option existed;

2. Determine the cost to transport commodities between the Uinta Basin and a connection with the national rail system, given the results of the previous task, assuming the construction of the prospective railroad built on one of three previously identified rail alignments:

    - Myton/Leland Bench Area, UT - Rifle, CO, via Meeker Area;
    - Myton/Leland Bench Area, UT - Rifle, CO, via Piceance Creek; and
    - Myton/Leland Bench Area, UT - Craig, CO.

3. Compare the rail transportation costs developed in the previous task to the cost of alternative transportation options to a connection with the national rail system, including:

    a. Trucking between the Myton/Leland Bench Area and a rail transload facility at Price, UT, and
    b. Piping between the Myton/Leland Bench Area and a rail transload facility at Price, UT;

4. Compare the cost to transport crude oil between the Uinta Basin and Salt Lake City area refineries via the five (three potential rail alignments, trucking/transloading, piping/transloading), al-

ternative transportation options previously identified and trucking direct from the Myton/Leland Bench Area;

5. Determine the cost to transport commodities between the Uinta Basin and markets reached on the national rail system via the three, identified connections (Rifle, CO, Craig, CO and Price, UT); and

6. Offer recommendations based on the conclusions reached through the performance of the above-described tasks.

1.2 RLBA Approach to the Scope of Work

To address these tasks, RLBA developed and applied a three-part approach, including:

1. Determining Potential Rail Traffic Volumes, Destinations and Origins;
2. Determining Costs to Reach a Connection with National Rail Network and
3. Determining Costs to Ship Across the National Rail Network to/from Distant Markets.

1.3 Approach Part 1 - Determining Potential Rail Traffic Volumes, Destinations and Origins

For any new build rail project in the Uinta Basin to be successful, there must be a clear and accurate understanding of the commodities and volumes likely to be transported out of or into the Uinta Basin. While crude oil is likely to constitute the majority of volume shipped on any prospective railroad in the Uinta Basin, the flexibility offered by rail affords opportunities to ship other commodities both related and not related to crude oil production which could greatly improve the economic feasibility of the prospective railroad. To determine both the volume of crude oil, as well as to identify and gauge the volumes of other commodities that could potentially ship via rail, RLBA undertook a two-step process. First, leveraging data supplied by the SCIC, RLBA compiled a comprehensive list of potential rail customers and other important stakeholders. RLBA then conducted both over–the-phone and on-site interviews with said potential customers and stakeholders to identify: 1) their potential interest in shipping via rail; 2) their anticipated rail volumes should a connection be built; 3) ideal origin/destination points of shipments via rail; 4) current trucking rates; and 5) any other relevant information. Second, RLBA took the information gathered from potential rail customers and stakeholders and developed a detailed volume forecast of commodities to be transported both into and out of the Uinta Basin in the event the prospective railroad was constructed.

The methodologies, findings and conclusions regarding this step are detailed in section 2 of this report. Additionally, conclusions regarding Task 1 (determination of commodities, volumes and destinations which could be expected to be shipped into and out of the Uinta Basin by rail if a rail transportation option was built) are also addressed in section 2 of this report.

1.4 Approach Part 2 - Determining Costs to Reach the National Rail Network

Transportation cost into and out of the Uinta Basin consist of two components: 1) the cost to transport commodities between the Uinta Basin and a connection with the national rail network, a component which would be addressed by the construction of the proposed railroad; and 2) the cost to transport commodities between this connection with the national rail network and a final destination/origin via the major national railroad(s) providing the connection to the national rail network.

Once the commodities and volumes potentially coming into and out of the Uinta Basin were understood, RLBA used this data to determine the cost to transport said commodities in and out of the Uinta Basin area on the prospective railroad – the first of the two components constituting the cost of transportation. To determine said transportation costs on the prospective railroad, RLBA undertook a two-step process. First, regarding each rail alignment option, RLBA developed an operating plan unique to the specific characterization of that alignment. Second, RLBA applied real world costing data to said operating plan, drawn from proprietary databases maintained by RLBA, to provide highly accurate cost estimations in connection with each rail option based on the characteristics of each potential alignment provided to RLBA. Beyond determining the transportation costs associated with the prospective railroad, these estimations also were used to compare transportation costs associated with alternative transportation options into and out of the Uinta Basin.

The methodologies, findings and conclusions regarding this step are detailed in section 3 of this report. Additionally, conclusions regarding Task 2 (determination of the cost to transport commodities between the Uinta Basin and a connection with the national rail system, assuming the construction of the prospective railroad entity), Task 3 (comparison of the rail transportation costs to the costs of alternative transportation options to/from a connection with the national rail system), and Task 4 (comparison of the costs to transport crude oil between the Uinta Basin and Salt Lake City), are also addressed in section 3 of this report.

1.5 Approach Part 3 - Determining Costs to Ship across the National Rail Network to/from Distant Markets

While important, determining the transportation cost between the Uinta Basin and the national rail network is only one of the two components of the true transportation cost into and out of the Uinta Basin. Once commodities have reached the national rail network, a major national railroad – either Union Pacific or BNSF Railway, depending on the junction location – must be engaged to perform final or interchange delivery. Because a major railroad will handle Uinta commodities for the majority of the trip to/from distant markets, a major railroad's rates likely will be the single largest cost component encountered by prospective rail shippers to and from the Uinta Basin.

The final 'piece of the puzzle' in determining the feasibility of a new rail line to the Uinta Basin is understanding what the major railroads – either Union Pacific or BNSF Railway – will charge to transport any material into or out of the western Colorado. Combining information from proprietary databases maintained by RLBA, industry leading third-party rate estimation software to which RLBA subscribes and real-world rail rate data maintained and provided by the Surface Transportation Board ("STB") – the fed-

eral entity tasked with economic oversight of the railroad industry – RLBA developed estimated shipping rates specific to the origins and destinations of the specific commodities potentially being shipped into and out of the Uinta Basin. Additionally, RLBA determined lease rates associated with the rail equipment required to ship Uinta Basin's outbound and inbound freight commodities over the national rail network.

The methodologies, findings and conclusions regarding this step are detailed in section 4 of this report. Additionally, conclusions regarding Task 5 (determination of the costs to transport commodities between the Uinta Basin and distant markets) are also addressed in section 4 of this report.

1.6 The Prospective Railroad

For purposes of this report, RLBA has identified the prospective railroad as the "Uinta Basin Railroad" (herein referred to as the "UBRR"). It is assumed that the UBRR would open as a regulated, common carrier in 2022. Per the request of SCIC, this study focuses on a twenty year period spanning from the commencement of operations in 2022 until 2042.

There have been a variety of studies regarding the potential construction of a railroad in the Uinta Basin dating back to at least 1981. Most pertinent of these studies to RLBA's work is the study entitled "Feasibility Report for the Isolated Empire Rail Project," completed in 2001 by DMJM Harris (herein referred to as the "2001 DMJM Harris Study"). This study, among other things, considered 16 potential rail alignments between the Uinta Basin and a connection with the national rail network, ultimately recommending five alignments for further study. For purposes of this report, RLBA was instructed by SCIC to consider three of these five rail alignments. In part to support RLBA's work, SCIC engaged a third party engineering firm, Jones & DeMille Engineering (herein "Jones & DeMille"), to provide updated conceptual level engineering plans and construction cost estimates in connection with each of the three alignments identified in the 2001 DMJM Harris Study and selected for inclusion in this study.

The following is a description of the important elements of these alignments, illustrated in Map 1-1.

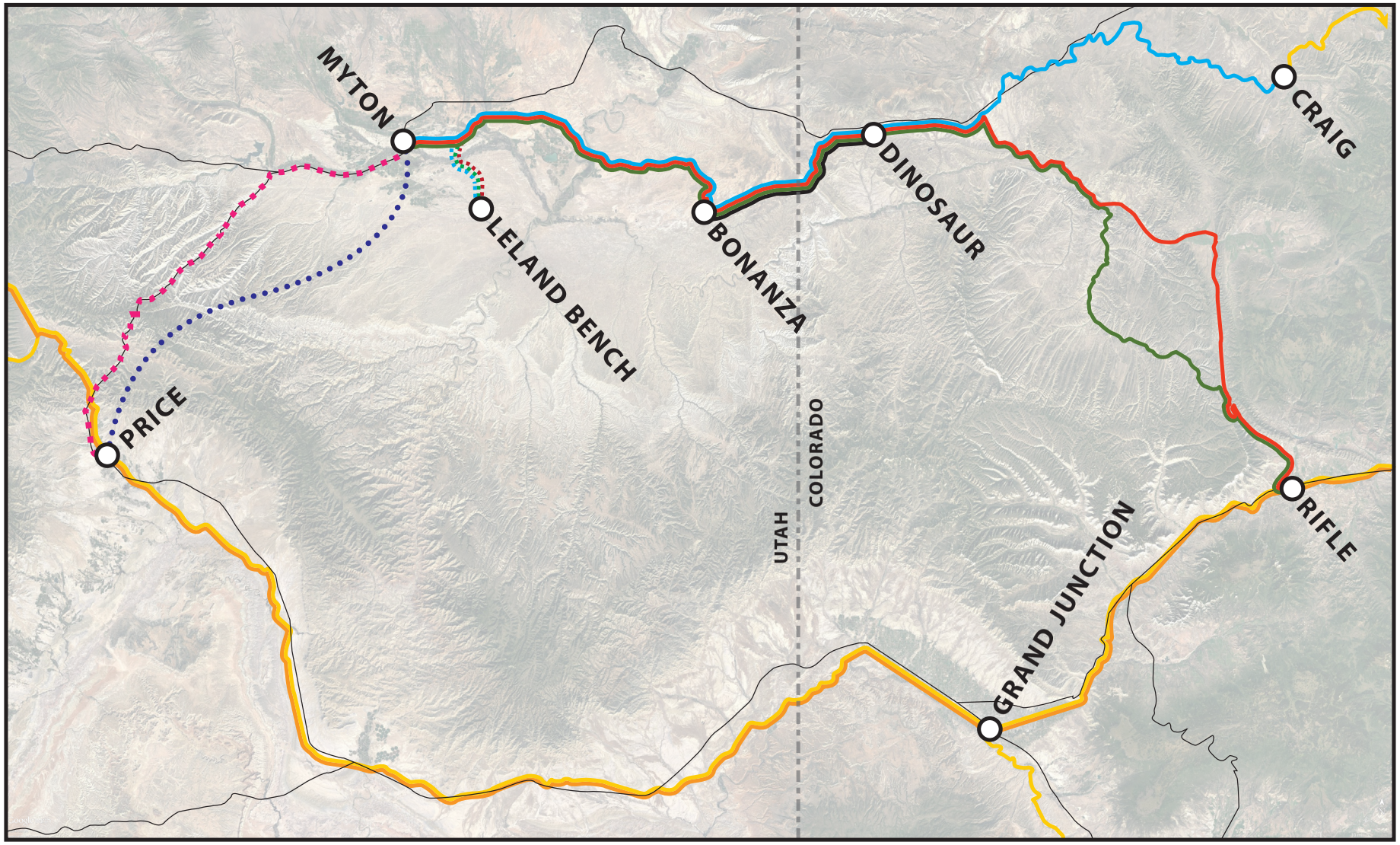
1.7 Western Terminus - Uinta Basin

Through conversations with SCIC and interviews with various stakeholders it was determined that the western end of UBRR would be located in one of two (but not both) locations:

1. **Myton, UT** - A small community of approximately 600, located within the Uinta Basin along U.S. Routes 40 and 191. Due to its location on U.S. 40 and 191, Myton features reasonably developed road infrastructure. The community is an important hub for the Utah oil industry; the regional headquarters of Newfield Exploration Company, a leading crude oil producer in the region, is located in Myton. Additionally, Chevron Corporation's Rangeley, CO – Salt Lake City, UT pipeline passes several miles to the south of Myton. Myton was identified as the western terminus in the 2001 DMJM Harris Study and

2. **Leland Bench, UT** - An unincorporated community approximately 12 miles southeast of Myton. Leland Bench currently features very limited road infrastructure and no industrial or rail infra-

Map 1-1
Map of Proposed Rail Alignments in the Uinta Basin



Map not necessarily to scale, not all lines shown
Base Map: Google Earth Pro; Map Data: Landset / Copernicus

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structure. However, Uintah Advantage (see section 2.9) has expressed interest in developing a refinery at Leland Bench. Additionally, Uintah Advantage has suggested land could be made available for the construction of rail facilities at the Leland Bench site at little or no cost to the railroad. As such, Leland Bench was identified as a potential alternate location as the western terminus of the UBRR by SCIC.

The values advanced in this study regarding capital costs as well as operating and maintenance costs were developed assuming that the UBRR terminated in Myton, However, Jones & DeMille determined that the difference in construction cost to build the proposed railroad to either Myton or Leland Bench would be negligible. Specifically, it would cost approximately $13 million more to build to Leland Bench – which correlates to an approximately 1.15% increase in the overall initial construction cost. To reach Leland Bench, the prospective rail alignment would remain largely the same as that to reach Myton, the only difference being that the alignment would turn due south in the vicinity of Randlett, UT to reach Leland Bench. RLBA also determined that, in general, the mileages and physical characteristics of the railroad to either Myton or Leland Bench would be comparable. As such, it reasonably can be assumed that the conclusions reached in the study are valid regardless of which location is ultimately selected as the railroad's terminus and, therefore, are used interchangeably throughout this report.

Regardless of which location is assumed to be the western terminus of the railroad, both would require substantial investment in both transportation and petroleum production-related infrastructure to adequately meet the needs of the proposed railroad. This study only considers the investment required to construct and operate the required rail infrastructure.

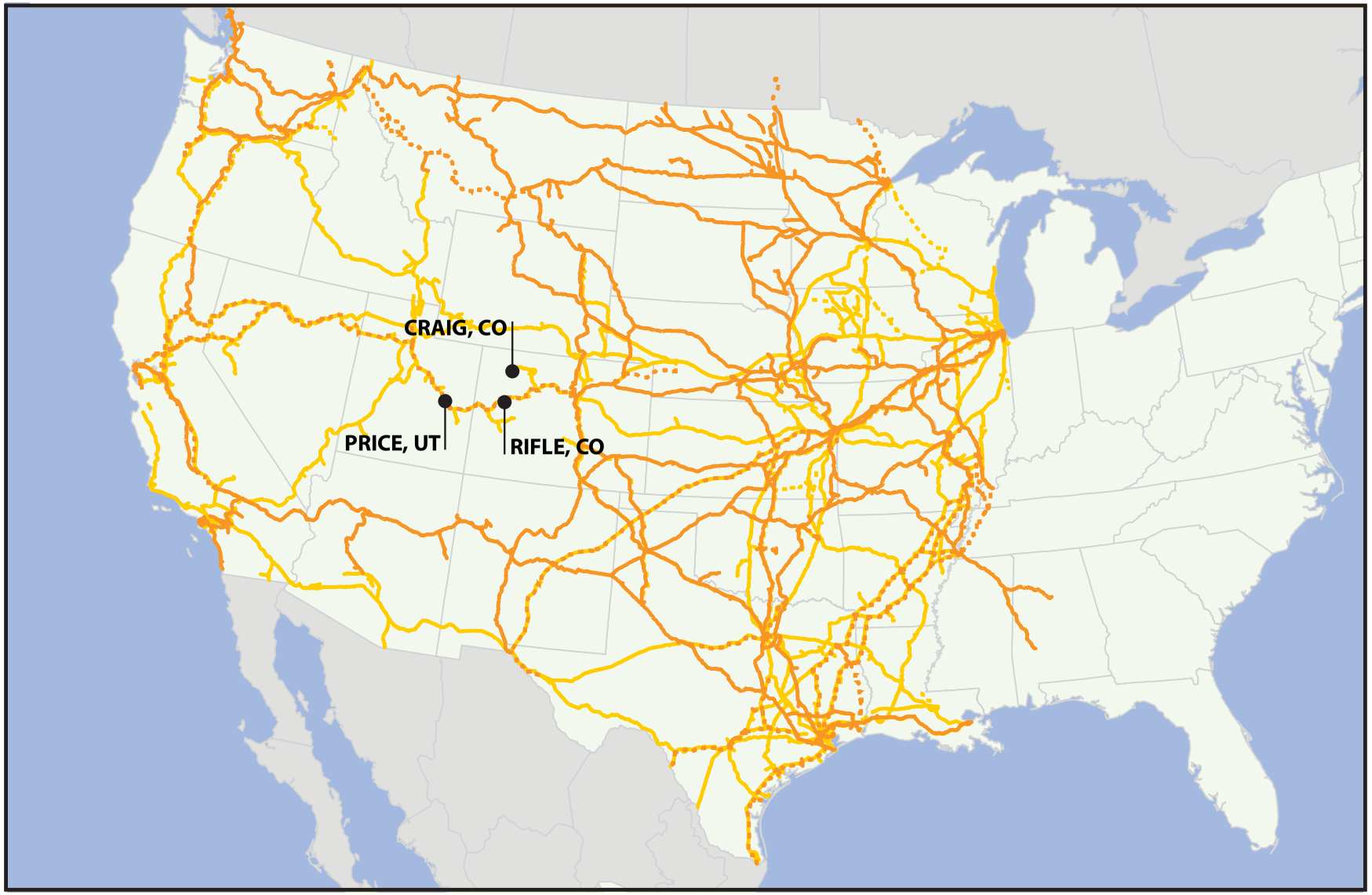
1.8 Eastern Terminus - Connection with the National Rail Network

The three, potential rail alignments ultimately selected by SCIC from the 2001 DMJM Harris Study all terminate at a connection with the national rail network at one of two locations. Depending on the location, the terminus would allow for a connection with the national rail network with one or two, major, national railroads –Class One railroads, as defined by the STB - either via Union Pacific or Union Pacific (herein referred to as the "UP") and BNSF Railway (herein referred to as the "BNSF"). UP is the largest railroad in the United States in terms of revenue, operating a 32,100 mile network in 23 western states. BNSF is the second largest railroad in the United States in terms of revenue and UP's largest competitor, operating a 32,500 mile network in 28 western states. Their vast networks are illustrated in Map 1-2.

Thest two locations are:

1. **Rifle, CO** - A community of approximately 9,000, located along the UP Central Corridor. The Central Corridor is a secondary mainline extending between Denver, CO and Winnemucca, NV by way of Salt Lake City, UT. Previously the mainline of the Rio Grande & Western Railroad, and subsequently the Southern Pacific Transportation Company, since being acquired by Union Pacific in 1998, the majority of rail traffic on the line has been shifted to Union Pacific's original mainline through Wyoming. Today, the majority of traffic on this portion of the Central Corridor through Rifle consists of unit coal trains, limited general freight and Amtrak's California Zephyr. Of note, coal traffic volume on the line has been significantly and negatively impacted by the

Map 1-2
Map of Union Pacific and BNSF Railway Networks



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national downturn in both coal production and consumption. Additionally, as part of the Union Pacific's acquisition of the line, BNSF retains the right to both operate trains over and to directly serve new railroads and select customers along the Central Corridor according to its representatives interviewed by the study team. As such, were the UBRR constructed to Rifle, Uinta Basin shippers would have the luxury of connecting with two, major railroads instead of one.

2. **Craig, CO** - A community of approximately 9,000, located along the UP Craig. The Craig Branch is a tertiary feeder line, connecting Craig with the aforementioned Central Corridor at Bond, CO, a distance of approximately 100 miles. Historically, the Craig Branch served an important coal producing territory, connecting several mines to power plants in Denver and beyond. However, much as on the larger Central Corridor, recent downturns in the national coal market have led to a significant reduction in the volume of coal being transported over the line. While coal still accounts for the majority of traffic on the line, there are some customers in the Craig area who receive general freight service. Importantly, unlike Rifle, BNSF does not have the ability to reach or serve customers or new railroads on the Craig Branch. If the UBRR were constructed to Craig, rail customers would have no alternative but to ship on UP.

Through conversations with SCIC and interviews with various stakeholders, RLBA determined that one of the driving forces behind the consideration of Rifle as one of the potential eastern termini of the UBRR was the desire to connect to both UP and BNSF instead of only with UP. Interviewed stakeholders repeatedly stated that connections to both railroads could result in significantly improved service and pricing. RLBA's extensive experience in railroad economics corroborates those expectations.

There are at least two major ways in which connections with any two Class One railroads are likely to result in lower railroad rates (transportation costs) and better service than a connection with only one railroad would yield. First, while UP is the largest railroad in the United States - which suggests that it reaches many of the destinations to which oil and other commodities found or mined in the Uinta Basin will be destined – there are destinations not directly accessed by UP but which are served by BNSF. What's more, BNSF may offer better, more direct routing to certain destinations served by both railroads, an advantage which could result in lower transportation rates paid by prospective Uinta Basin rail shippers. Second, there is the potential to create some price competition between UP and BNSF to and from those locations that are served directly by both, as well as those that are served by another railroad but which third party can and does interchange with both UP and BNSF. One would expect the presence of a second, major rail carrier to result in more vigorous price competition, again, resulting in prospective Uinta Basin rail shippers realizing lower rail transportation rates and therefore higher profits than would be the case in the event the UBRR connected with only one carrier.

1.9 Potential Alignments

The three rail alignments considered for the UBRR include:

1. **Myton/Leland Bench Area, UT - Rifle, CO via Meeker Area** - This alignment heads roughly due east from Myton/Leland Bench, crossing the Green River before connecting to the Deseret Power Railroad at Bonanza, UT (see section 1.11). The alignment continues along the existing Deseret

Power Railroad until Dinosaur, CO, then continues east to the Massadona, CO area, at which point the alignment heads south to White River City, CO. The alignment then follows the White River eastward to Meeker, CO, where the alignment heads south over the Rio Blanco Pass before arriving at Rifle, CO and a connection with the Union Pacific Central Corridor.

The total length of the alignment would be 183.31 miles (including 152.97 new-build miles), operating through predominately rolling hills and mountainous terrain. According to the 2001 DMJM Harris Study, the alignment "contains 9° curves and switchbacks to gain elevation, making the grade 2.5% for approximately nine miles. Other segments of the route are at 2.5% grade for 1 to 1.5 miles. The inbound 2.5% grade is the ruling grade for the route." These characteristics suggest the alignment would be demanding, challenging, and therefore more expensive to construct, maintain and operate than a typical rail line.

2. **Myton/Leland Bench Area, UT - Rifle, CO via Piceance Creek** - This alignment heads roughly due east from Myton/Leland Bench, crossing the Green River before connecting to the Deseret Power Railroad at Bonanza, UT. The alignment continues along the existing Deseret Power Railroad until Dinosaur, CO, then continues east to the Massadona, CO area, at which point the alignment heads south to White River City, CO. The alignment then continues southeast along Piceance Creek before crossing Rio Blanco Pass, arriving at Rifle, CO and a connection with UP's Central Corridor.

   The total length of the alignment would be 185.13 miles (including 154.80 new-build miles), operating through predominately rolling hills and mountainous terrain. According to the 2001 DMJM Harris Study, the line "contains 9° curves and switchbacks to gain elevation, making the grade 2.5% for approximately nine miles. Other segments of the route are at 2.5% grade for 1 to 1.5 miles. The inbound 2.5% grade is the ruling grade for the route." These characteristics suggest the alignment would be demanding, challenging and therefore more expensive to build, maintain and operate than a typical rail line.

3. **Myton/Leland Bench Area, UT - Craig, CO** - This alignment heads roughly due east from Myton/Leland Bench, crossing the Green River before connecting to the Deseret Power Railroad at Bonanza, UT. The alignment continues along the existing Deseret Power Railroad until Dinosaur, CO, then continues east, roughly paralleling U.S. Route 40 until reaching the Yampa River. The alignment then follows the Yampa River through Elk Springs Pass before arriving in Craig and a connection with UP's Craig Branch.

   The total length of the alignment would be 157.27 miles (including 126.93 new-build miles), operating through predominately rolling hills and flat terrain. According to the 2001 DMJM Harris Study, the line features "6° curves maximum. The ruling grade for this route is 2.0%, with most grades at 1.8% or less. The 2.0% sections occur at the Craig end of the route and just to the west of Elk Springs." While presenting challenges to the operating and maintenance of the line, these characteristics are significantly less extreme than those observed on either Rifle alignment, resulting in likely lower costs to build, maintain and operate the line.

1.10 Shared Alignments

All three potential rail alignments share a common alignment between Myton and/or Leland Bench, UT and in the vicinity of Massadona, CO. At Massadona, CO, the two potential Rifle rail alignments turn southeast, continuing on the same, shared alignment, while the potential Craig rail alignment continues eastward on a unique alignment. The two potential Rifle rail alignments continue on a shared alignment between Massadona, CO and White River City, CO, before splitting, with one alignment heading southward towards Piceance Creek and the other continuing eastward towards Meeker, CO, before turning southward. The two alignments then rejoin in the vicinity of Rio Blanco Pass, where both again share the same alignment over the remainder of the distance to the end of the line/proposed interchange location at Rifle, CO.

1.11 Deseret Power Railroad

Built in 1983 and owned by Blue Mountain Energy, the Deseret Power Railroad (DPR) was constructed to transport coal between the Deserado Coal Mine outside of Dinosaur, CO, and the Bonanza Power Plant outside of Bonanza, UT. The integration of the DPR right-of-way would result in significant cost savings to the overall project. To that end, RLBA interviewed DPR management to, among other topics, determine the company's level of interest in cooperating with any effort to construct the proposed UBRR. While no specifics terms or requirements were discussed, in general the management of the DPR expressed a willingness to cooperate with any such efforts, assuming that: 1) the company's rail operations could continue unimpeded; 2) any required infrastructure improvements would be paid for the UBRR; and 3) some agreement was reached regarding the maintenance of the railroad.

As a result of the interview, this study reflected the assumption that approximately 32 route miles of the existing DPR right-of-way, between Bonanza, UT and Dinosaur, CO, would be integrated into the construction of the UBRR, regardless of which alignment was chosen. A unique feature of the DPR is the use of electric locomotives and an accompanying overhead catenary system, which limits overhead clearance on the railroad to 22 feet. RLBA determined that all railcars used to transport the commodities likely to be transported on the UBRR would not exceed this 22foot limit. As such, integration of the DPR would not negatively impact operations on the UBRR or vice versa. Given the preliminary nature of the discussions with DPR management, RLBA made no assumptions regarding the nature of any commercial arrangement or agreement involving potential use of the DPR. RLBA, however, did assume that all costs associated with infrastructure improvements on the DPR and all maintenance expense on the integrated portions of the DPR would be borne by the UBRR.

2.0 Approach Part 1 - Determining Potential Rail Traffic Volumes, Destinations and Origins

2.1 Summary of RLBA Approach

RLBA employed a two-step process to determine the potential rail traffic volumes, destinations and origins, including:

1. Conducting interviews with prospective Uinta Basin rail shippers and other stakeholders; and
2. Developing Higher and Lower forecast volumes.

2.2 Conducting Interviews with Prospective Uinta Basin Rail Shippers and Other Stakeholders

The foundation of the forecast volumes used in this report was a series of interviews conducted by RLBA based on a preliminary list assembled by SCIC. RLBA acknowledges the significant effort SCIC's Executive Director went through to contact those interviewed, to create an aggressive but efficient interview schedule and to attend and take notes during almost all of the interviews discussed below. The interviews are best understood as falling into three categories:

1. **Non Shipper, Stakeholder Informational Interviews** - These interviews were conducted at a higher and more generic level than the others. They were designed to familiarize RLBA staff with both the opportunities potentially available were a rail solution found to be viable as well as the potential challenges to such a rail solution, both now and in the future. These interviews were conducted during a relatively short time frame via individual conference calls, primarily in the week before May 6. Included among the entities interviewed were representatives of both UP and BNSF. There were 11 such interviews.

2. **Prospective Uinta Basin Rail Shipper Customer/Commodity Interviews** - These interviews largely took place during a single, intensive week between May 6 and May 11 and were conducted in person in Denver, CO, Vernal, UT, Salt Lake City, UT and the Houston, TX metropolitan area. Additional, follow up interviews to seek clarification of issues related to forecast volumes were conducted as necessary. The information gathered in these interviews proved the most critical to development of rail traffic volume forecasts. There were 14 such interviews.

3. **Prospective End User Interviews** - End user interviews were conducted in person by Marc Eckels, an independent consultant (see section 2.4) under contract to SCIC and took place in the Houston, TX metropolitan area during one week in the middle of June. These interviews were focused entirely on potential consumers of the Basin's crude oil, as RLBA decided during the course of the study that the end product would be enhanced by detailed discussions with potential purchasers of the Uinta Basin's oil since the oil has not had a chance to prove itself to most of its potential customers. There were 5 such interviews, covering 11 potential end user refineries.

A comprehensive list of the interview type, interview location, company interviewed, refinery location (where relevant) and the name of the individual interviewed, is included in Table 2-1.

While all three types of interviews provided valuable information, the interviews with prospective Uinta Basin rail shippers' customers formed the primary basis of the rail traffic volumes forecasted by RLBA. From the perspectives of methodology and approaches, the prospective Uinta Basin rail shipper interviews are best understood as falling into three categories, including:

Table 2-1
List of Interviews Conducted by RLBA

Type	Location	Industy	Company
Customer/Commodity	Denver, CO	Crude Producer	Altamont Energy
Customer/Commodity	Vernal, UT	Crude Producer	Anadarko
Customer/Commodity	Denver, CO	Crude Producer	Axia
Customer/Commodity	Denver, CO	Crude Producer	Crescent Point
Customer/Commodity	Houston, TX	Crude Producer	EP Energy
Customer/Commodity	Houston, TX	Crude Producer	Newfield
Customer/Commodity	Conference Call	Fly Ash	Deseret Generation
Customer/Commodity	Vernal, UT	Frac Sands	Goodrich Mud
Customer/Commodity	Vernal, UT	Gilsonite	N/A
Customer/Commodity	Salt Lake City, UT	Oil Shale	Enefit American Oil
Customer/Commodity	Salt Lake City, UT	Refinery	Uintah Advantage
Customer/Commodity	Conference Call	Sodium Bicarbonate	Natural Soda
Customer/Commodity	Conference Call	Steel Pipe	CTAP
Customer/Commodity	SLC	Unconventional Fuels	Red Leaf Resourses
End User	Houston, TX	Refinery	Chevron
End User	Houston, TX	Refinery	ExxonMobil
End User	Houston, TX	Refinery	Marathon Petroleum
End User	Houston, TX	Refinery	Motiva
End User	Houston, TX	Refinery	Shell/Pemex
Informational	Conference Call	Class 1 Railroad	BNSF
Informational	Conference Call	Class 1 Railroad	Union Pacific
Informational	Conference Call	Key Stakeholder	Ute Indian Tribe
Informational	Salt Lake City, UT	Refinery	Utah Petroleum Association
Informational	Conference Call	Specialized Info	DC Welding & Construction
Informational	Conference Call	Specialized Info	Global One/ WATCO
Informational	Conference Call	Specialized Info	L&P Logistics
Informational	Conference Call	Specialized Info	Petroleum Experts
Informational	Conference Call	Specialized Info	Sage Energy
Informational	Vernal, UT	Trucking	Brady Trucking
Informational	Conference Call	Trucking	Savage

1. **Prospective Uinta Basin Rail Shippers Currently Using Existing Rail Transportation Options** - Consisting of prospective Uinta Basin rail shippers that are already transporting commodities to or from the Uinta Basin for their own account, in competition with other suppliers via trans-load between rail and truck. In this category, RLBA sought to understand the total volume of that commodity moving today by truck to or from the Basin and to understand how that volume might change in the future, especially if oil production increased significantly. Frac sand and steel pipe are excellent examples of commodities in this category.

2. **Prospective Uinta Basin Rail Shippers Currently Not Using Rail** –Consisting of prospective customers that hope to generate or consume freight volume that would move by rail in the future.

Because of the more speculative nature of these prospects, RLBA used Higher and Lower forecasts, with Lower forecasts reflecting lower, later developing or no forecasted rail carloads and Higher forecasts reflecting the dates and volumes presented by the interviewee, translated into carloads.

3. **Prospective Uinta Basin Rail Shippers with Limited Traffic Volume Forecasting Ability** - Forecasts of conventional oil production were handled a third way that RLBA deemed more appropriate to the situation. More specifically, attempts to use a more conventional approach to forecasting potential use of the UBRR by crude oil producers would have been thwarted by the fact that producers don't tend to forecast as far into the future as required to support prospective railroad carloads and that production is distributed across a large number of producers. So, in the alternative, RLBA decided to discuss potential total Uinta Basin production with almost all of the largest producers currently in the Basin and to use the extremes manifest in their estimates to drive its Lower and Higher carload forecasts. Further detail on RLBA's Higher and Lower forecasts for each commodity can be found in the following sections.

2.3 Developing Higher and Lower Forecast Volumes

The railroad industry is different from most other industries in two major ways: 1) it requires a small cost of materials relative to revenues earned to produce its outputs; and 2) it also requires a high capital investment relative to revenues. However, once a railroad achieves a break-even level of freight traffic, a surprisingly large percentage of incremental revenue drops to the "bottom line" as traffic is added and a railroad can become highly profitable when measured against just about any metric except return on invested capital. A common expression of this phenomenon is that the railroad industry is said to manifest extremely high operating leverage. As a result, for a railroad to succeed, it must attract and keep a significant volume of traffic on which it can charge competitive rates. The need to achieve and sustain a high volume of traffic and revenue is even more critical in the case of a railroad such as that investigated herein because the financial performance of the Uinta Basin Railroad will be tested further by the need to overcome the extremely high capital costs that are a necessary element of a railroad being constructed in excess of 126 miles.

As a consequence of the above, it is absolutely essential that the SCIC be provided one or more traffic volume and associated revenue forecasts in which it can repose confidence. Through the course of the study, RLBA determined there to be four significant potential challenges to the achievement of the projected volumes forecasted herein, including:

1. **Stability of the Future Price of Oil** - The World oil market has been anything but stable since 1973, and there is every reason to think that such volatility might continue. The viability of the UBRR is grounded on the assumption that oil markets will be stable or favorable, which is a reasonable assumption to make. However, a significant and long-term downturn in the price of WTI, particularly in the early years of the prospective railroad, could result in significant shortfalls from the performance indicated herein;

2. **Barriers to Timely Construction of the UBRR** - There are risks that permits or financing as-

sociated with the UBRR might be denied or delayed significantly, to the point that prospective Uinta Basin rail shippers might seek alternative "take away" capability or divert investment dollars to other regions, thereby diverting or postponing volumes of crude oil and other commodities which otherwise might traverse the UBRR;

3. **Reluctance to Commit** - While the economics of the UBRR may be promising, the region's producers might be reluctant or otherwise unable to make the commitments necessary to secure financing, even if such assurances are ultimately required to advance the project and;

4. **Unknown Demand** - The demand for Uinta Basin's waxy crude, which is not well known outside of Utah, in large part due to lack of transportation infrastructure to ship product out of the Uinta Basin, may not be as readily accepted as initial indications would suggest. While there appear to be a large number of refineries at least prospectively interested in Uinta Basin crude, additional work should be undertaken to increase the likelihood that sufficient demand will manifest itself by the time the UBRR is about to be constructed. Ideally, that demand will manifest itself not only in interest expressed by out-of-state refineries that the Basin's waxy crudes have been modeled successfully by the refineries, but also that the volumes desired are significant enough in total to consume the supply side at pricing at or near WTI taking into consideration the need to unload unit trains at or nearby refineries to keep rail transport costs to a minimum, and that arrangements already have been or can be made to provide sufficient heating to prevent the waxy crude from "setting up."

In light of these challenges, to best define the potential volumes, RLBA developed forecasts of the carloads it believes are reasonable to assume would be carried by the prospective railroad during the period 2022 through 2034 (and every year beyond) were it built, managed and operated at a reasonable cost. More specifically, RLBA developed "Lower" and "Higher" forecasts in connection with crude oil and seven other commodities it believes might be hauled on that railroad in its early years.

A summary of estimated annual Higher and Lower forecasts of various commodities is shown in Table 2-2.

The carloads in the Higher forecast reflect assumptions made by RLBA consistent with a theme that decisions would be made that would result in actions that would be favorable to the prospective railroad's viability. Primary among those favorable assumptions is that Basin oil producers will be able and motivated to extract, and market conditions will encourage the extraction of, no less 225,000 bpd on a consistent basis if the railroad is built and operated as presently envisioned. That threshold volume has been articulated by several major oil producers in the Basin even though it represents almost a tripling of recent production volumes there. The application of those assumptions results in a forecast of 95,753 carloads over the prospective railroad in its first full year, 2022, in the Higher case and 302,495 carloads hauled by that railroad in the Higher case in 2034 and beyond. As a sensitivity test, RLBA also developed a Lower case in which 41,629 carloads were forecast to be carried in 2022 and 137,510 were assumed to be hauled in 2034 and beyond.

Table 2-2
Estimated Annual Carloads Originating/Terminating in Uinta Basin, 2022-2044

	Crude Oil		Other Outbound		All Inbound		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	7,485	65,586	13,377	2,400	20,767	27,767	**41,629**	**95,753**
2023	22,456	109,785	13,377	2,400	24,863	49,223	**60,696**	**161,408**
2024	51,685	153,984	13,377	2,400	28,957	68,600	**94,018**	**224,984**
2025	78,787	157,064	9,955	2,400	33,053	69,972	**121,795**	**229,436**
2026	82,695	160,205	9,955	16,783	35,100	71,371	**127,750**	**248,360**
2027	83,522	163,409	9,955	16,783	35,451	72,799	**128,928**	**252,991**
2028	84,357	166,678	9,955	16,846	35,806	74,255	**130,118**	**257,778**
2029	85,201	170,011	9,955	24,037	36,164	75,740	**131,319**	**269,788**
2030	86,053	173,411	9,955	31,166	36,525	77,255	**132,533**	**281,832**
2031	86,914	176,880	9,955	31,166	36,890	78,800	**133,759**	**286,845**
2032	87,783	180,417	9,955	31,166	37,259	80,376	**134,997**	**291,959**
2033	88,661	184,026	9,955	31,166	37,632	81,983	**136,247**	**297,175**
2034 +	89,547	187,706	9,955	31,166	38,008	83,623	**137,510**	**302,495**

In both the Higher and Lower cases, railroad volumes were assumed to ramp up in the early years of the forecast, driven by increased production of crude oil in the Basin and the inputs that enable same, as well as greater and greater acceptance of the Basin's crudes at various refineries, primarily located in Gulf Coast states. Similarly, and perhaps more importantly, the viability of the prospective railroad is extremely dependent upon and sensitive to assumptions made about the ramp up rate and total production of crude oil in the Basin. Not only is crude oil by far the largest single commodity moved on the prospective railroad, but frac sand and steel pipe movements into the Uinta Basin, supporting the production of crude oil are obviously equally dependent upon how much oil is extracted in the Basin and are also significant contributors to the prospective railroad's viability.

2.4 Additional Study Contributions

To further assist in the study, the SCIC contracted with Marc Eckels, an experienced oil and gas consultant based in Park City, UT, to interview representatives of select refineries primarily in the Gulf Coast and discuss with them in detail, to the extent possible, the prospective interest of those refineries in the Basin's oil. After interviewing in person representatives of five companies operating eleven refineries believed to be possible consumers of Basin crudes, Mr. Eckels concluded that demand exists today for at least somewhere between 320,000 and 340,000 bpd of Basin oil.

Several caveats should be taken into consideration in digesting that forecast. First, and most importantly, the work performed by Mr. Eckels is not complete, as he was only able to meet with officials representing eleven of the nineteen refineries he originally targeted. It is the intent of Mr. Eckels to make a good faith effort to complete interviews with representatives of the remaining eight refineries. As such, the results of this report are subject to change pending the outcome of said interviews.

Second, although most of the representatives expressed few reservations about taking Basin crude, no large and sophisticated refinery is going to commit to actually adding new crude into its mix until it runs the characteristics of that crude through its proprietary model. And while there are several characteristics of the Basin's crude oil that should make it extremely attractive to many large refiners, most are still a long way from signing a contract committing them to taking significant volumes of Uinta Basin crude.

Additionally, the volumes of crude that the Basin's oil producers have been able to market have been highly constrained by the region's transportation infrastructure limitations, particularly the absence of a railroad or pipeline. These transportation limitations are the primary cause of the unique market factors present in the region. Regarding price, Mr. Eckels concluded that it was extremely likely that the refineries he targeted would be willing to pay no less than a small discount to WTI and that some refineries might be willing to pay either WTI or perhaps even a slight premium to it, depending upon their marketing objectives and other factors. It is important to note for the record that no refinery representative explicitly promised or suggested that Basin producers absolutely would realize WTI from that refinery or close to it. It is equally important to note that the individuals interviewed are or previously were crude traders and traders could not reasonably be expected to "tip their hand" or reduce their negotiating leverage by agreeing in advance to pay WTI parity. While representatives of most refineries did not provide indicative pricing relative to WTI, one offered an indication at a $3 to $5 discount to WTI. This discount would compare favorably to the one realized today by most major Basin producers, which recently has been in the neighborhood of WTI minus 17%.

2.5 Methodologies Used to Determine Potential Rail Traffic Volumes, Destinations and Origins

The following section provides a synopsis of the methodologies employed by RLBA to determine the potential rail traffic volumes, destinations and origins which would likely utilize the UBRR, if constructed.

2.6 Outbound Commodities

2.7 Crude Oil

RLBA employed separate assumptions about six, different factors to develop its Lower and Higher crude oil carload forecasts. Specifically, RLBA made assumptions about:

1. **Intermediate Term Crude Oil Production Potential** - Annual crude oil production in the Uinta Basin was assumed to be 225,000 bpd in the Lower forecast as a sensitivity test of the viability of the railroad hypothesized in this study. In contrast, a much higher figure, 350,000 bpd was employed in the Higher forecast, based on the oft-repeated pronouncements made by at least one of the leading oil producers in the Basin and other knowledgeable experts during interviews conducted in connection with this study effort;

2. **Volume of Production to Existing Salt Lake City Customers** - As regards the volume of total production destined to Salt Lake City refineries by truck and existing truck/rail transloading facilities after the prospective Uinta Basin railroad might become operational, 80,000 bpd was used

in the Lower forecast to approximate the volume that is usually destined to those five refineries largely by use of tanker trucks loaded in the Uinta Basin when the refineries are operating normally and the oil markets, likewise, are operating normally. In contrast, a lower figure, 40,000 bpd was assumed destined to the Salt Lake City refineries by truck in the Higher forecast. The lower truck diversion of crude oil to in-state refineries and away from potential new railroad haulage, results in a higher amount of crude available to be handled over the prospective railroad;

Although RLBA recognizes that its 40,000 bpd assumption of crude destined to the five in-state refineries would upset the status quo and could only come into play to the extent that long term supply contracts were not in place between Uinta Basin suppliers and the five refineries, RLBA, nevertheless believes that the lower diversion might arise for any one or more of at least three reasons. First, it might become less expensive to use the railroad to haul the oil to the Utah refineries than to continue to use trucks. Second, even if rail were not to prove less expensive to use than trucks to get to the five refineries, political pressure from the State of Utah and/or local governments, both in the Basin and between the Uinta Basin and refineries, might cause half of the volume to move by rail anyway because of the road congestion caused by the trucks, the safety and environmental issues caused by such extensive truck use and the maintenance costs incurred by Utah taxpayers to support continued use of the hundreds of daily truck movements necessary to handle the 80,000 bpd to those refineries. Finally, the oil producers in the Uinta Basin are fond of using the term "optionality" to describe their need to have optional markets other than Salt Lake City into which they can sell their oil if they are to expand production and escape from or improve upon the status quo WTI discount pricing they are currently forced to bear;

3. **Volume of Production Potentially Diverted to the Uintah Advantage Refinery (see section 2.9)** - It is difficult to argue that if the Uintah Advantage refinery comes into existence and consumes 40,000 bpd as forecast, it would be anything besides a big plus for oil producers in the Basin as they would immediately enjoy a decent sized, local consumer of their production and a refinery whose products would lower the overall cost of oil production by reducing the price of diesel oil products purchased locally while paying WTI or close to it. That said, the local consumption of Basin oil essentially translates into lower crude oil production available to be hauled on the prospective Uinta Basin Railroad to the extent the oil is refined into products consumed locally or not moved via the subject railroad. Therefore, in the Lower forecast, the refinery was assumed to be built and 40,000 bpd were diverted to that refinery although a lesser volume of products produced through the refinery were reflected in the Lower rail carload forecast, to capture refined products that would move by rail from the refinery; volumes that decline when Phase 2 of the project is assumed to come on line and result in an adjusted, refined product mix. In contrast, the Higher crude oil carload forecast reflects the assumption that the refinery is never completed and, therefore, no crude oil is diverted from local production into the local refinery and, likewise, no local refinery products are shipped via the subject railroad because the refinery was assumed to never be completed;

4. **Time Period of Production "Ramp Up" in Anticipation of the UBRR** - RLBA made assumptions about the year in which Basin oil production would begin to ramp up in anticipation of the prospective railroad's imminent start-up. In the Lower forecast, RLBA assumed that crude oil

producers in the Basin would not start to ramp up their production until the railroad was built and scheduled to commence operations in 2022. In contrast, in the Higher forecast, RLBA assumed that crude oil producers in the Basin would not wait to start ramping up their production until the railroad was scheduled to commence operations and started ramping up in 2020 in anticipation of same so that they could advance their respective enhanced sales volumes as soon as possible. Although RLBA acknowledges that oil producers are unlikely to act in complete unison, the assumptions employed to represent this factor were applied as if all producers acted uniformly across both Lower and Higher crude oil production forecasts;

5. **Rate of Production "Ramp Up" in Anticipation of the UBRR** - The fifth variable taken into consideration in the crude oil production forecasts was the rate of increase in production once ramping up of production commenced. In both the Lower and Higher crude oil production forecasts, RLBA's assumptions pivoted off of the net actual increase of 19,568 bpd that 9 drilling rigs accomplished in the 12 months between July 2016 and June 2017, or an increase of 1,631 bpd per month. RLBA's Lower forecast reflects a doubling of the rig count to about 18 and a concurrent approximate doubling of the growth to (1,631 bpd x 2 =) 3,262 bpd/month. Applying that rate of growth to 145,000 bpd growth in Basin bpd production inherent in the Lower forecast yields 44 months, which RLBA equated to four years in that forecast. While the tripling of the rig count may seem aggressive, that results in approximately the rig count in effect in the Basin in 2014. The Higher forecast incorporated the same approach but applied different numbers more appropriate to that scenario. Specifically, RLBA's Higher forecast reflects a quadrupling of the rig count to 36 and a concurrent quadrupling of the rate of growth to (1,631 bpd X 4 =) 6,524 bpd increase per month. Applying that rate of growth to the 270,000 bpd growth inherent in the 350,000 bpd overarching forecast in the Higher scenario equates to 42 months which, again, RLBA equated to four years. In other words, the ramp up period would be approximately the same in the two forecasts because the higher ramp up rate in the Higher forecast accomplished the ramp up to a higher ceiling in approximately the same time period as a slower ramp up to the Lower forecast production ceiling and

6. **Rate of Production After "Ramp Up" Period** - The sixth variable taken into consideration in the crude oil production forecasts was the rate of increase in production assumed once the initial ramping up period largely leveled off. In its Lower forecast, RLBA assumed a 1 % increase in production occurred each year as compared to that achieved in the previous year. In its Higher forecast, RLBA assumed a 2 % increase in production occurred each year as compared to that achieved in the previous year. RLBA believes that both assumptions are practical, achievable and, in fact, conservative (low) given the increases in production that have occurred in the last few years.

The application of these assumptions resulted in the following carload volumes and prospective destinations in the Higher and Lower forecasts, respectively.

Table 2-3
Crude Oil Carload Volumes, 2022-2042

Lower	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034+
Shreveport, LA	468	1,404	3,230	4,924	5,168	5,220	5,272	5,325	5,378	5,432	5,486	5,541	5,597
Pascagoula, MS	1,637	4,912	11,306	17,235	18,090	18,270	18,453	18,638	18,824	19,012	19,202	19,394	19,588
Baton Rouge, LA	585	1,754	4,038	6,155	6,461	6,525	6,590	6,656	6,723	6,790	6,858	6,927	6,996
Bayton, TX	585	1,754	4,038	6,155	6,461	6,525	6,590	6,656	6,723	6,790	6,858	6,927	6,996
Catlettsburg, KY	702	2,105	4,845	7,386	7,753	7,830	7,909	7,988	8,067	8,148	8,230	8,312	8,395
Garyville, LA	234	702	1,615	2,462	2,584	2,610	2,636	2,663	2,689	2,716	2,743	2,771	2,798
Galveston Bay, TX	234	702	1,615	2,462	2,584	2,610	2,636	2,663	2,689	2,716	2,743	2,771	2,798
Anacortes, WA	468	1,404	3,230	4,924	5,168	5,220	5,272	5,325	5,378	5,432	5,486	5,541	5,597
Port Arthur, TX	1,871	5,614	12,921	19,697	20,674	20,881	21,089	21,300	21,513	21,728	21,946	22,165	22,387
Norco, LA	234	702	1,615	2,462	2,584	2,610	2,636	2,663	2,689	2,716	2,743	2,771	2,798
Convent, LA	234	702	1,615	2,462	2,584	2,610	2,636	2,663	2,689	2,716	2,743	2,771	2,798
Deer Park, TX	234	702	1,615	2,462	2,584	2,610	2,636	2,663	2,689	2,716	2,743	2,771	2,798
Total	**7,485**	**22,456**	**51,685**	**78,787**	**82,695**	**83,522**	**84,357**	**85,201**	**86,053**	**86,914**	**87,783**	**88,661**	**89,547**

Higher	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034+
Shreveport, LA	4,099	6,862	9,624	9,817	10,013	10,213	10,417	10,626	10,838	11,055	11,276	11,502	11,732
Pascagoula, MS	14,347	24,016	33,684	34,358	35,045	35,746	36,461	37,190	37,934	38,692	39,466	40,256	41,061
Baton Rouge, LA	5,124	8,577	12,030	12,271	12,516	12,766	13,022	13,282	13,548	13,819	14,095	14,377	14,665
Bayton, TX	5,124	8,577	12,030	12,271	12,516	12,766	13,022	13,282	13,548	13,819	14,095	14,377	14,665
Catlettsburg, KY	6,149	10,292	14,436	14,725	15,019	15,320	15,626	15,939	16,257	16,582	16,914	17,252	17,597
Garyville, LA	2,050	3,431	4,812	4,908	5,006	5,107	5,209	5,313	5,419	5,527	5,638	5,751	5,866
Galveston Bay, TX	2,050	3,431	4,812	4,908	5,006	5,107	5,209	5,313	5,419	5,527	5,638	5,751	5,866
Anacortes, WA	4,099	6,862	9,624	9,817	10,013	10,213	10,417	10,626	10,838	11,055	11,276	11,502	11,732
Port Arthur, TX	16,396	27,446	38,496	39,266	40,051	40,852	41,669	42,503	43,353	44,220	45,104	46,006	46,927
Norco, LA	2,050	3,431	4,812	4,908	5,006	5,107	5,209	5,313	5,419	5,527	5,638	5,751	5,866
Convent, LA	2,050	3,431	4,812	4,908	5,006	5,107	5,209	5,313	5,419	5,527	5,638	5,751	5,866
Deer Park, TX	2,050	3,431	4,812	4,908	5,006	5,107	5,209	5,313	5,419	5,527	5,638	5,751	5,866
Total	**65,586**	**109,785**	**153,984**	**157,064**	**160,205**	**163,409**	**166,678**	**170,011**	**173,411**	**176,880**	**180,417**	**184,026**	**187,706**

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2.8 Shale Oil - Enefit

Enefit USA is the US subsidiary of a company based in Estonia that operates a mining enterprise in that country, using proprietary technology to mine shale there and turns it into heavy crude oil. After considering other geographic opportunities in which to expand its operations, the parent company elected to establish a US headquarters in Salt Lake City and make substantial investments both in property in the Uinta Basin as well as in commencing the permitting processes necessary to enable it to begin to mine shale in the Basin in the short-term.

In its Lower carload forecast, RLBA reflected the assumption that the project either stalled or never resulted in producing sufficient volumes to warrant inclusion in the subject forecast. Estimating when the permits might be obtained and production might commence is always challenging, but based on the interview RLBA had with the company's top U.S. executive its Higher forecast reflected the assumption that the plant would commence operations in mid-to-late 2025 and would generate approximately 14,258 carloads per year for three years, beginning in 2026, after which time volume would increase to a doubling of production, or 28,516 carloads per year, beginning in 2030.

The application of these assumptions results in the following carload volumes and prospective destinations in the Higher and Lower forecasts.

Table 2-4
Shale Oil Carload Volumes, 2022-2042

	Salt Lake City, UT		Los Angeles, CA		Houston, TX		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	0	0	0	0	0	0	**0**	**0**
2023	0	0	0	0	0	0	**0**	**0**
2024	0	0	0	0	0	0	**0**	**0**
2025	0	0	0	0	0	0	**0**	**0**
2026	0	14,258	0	0	0	0	**0**	**14,258**
2027	0	14,258	0	0	0	0	**0**	**14,258**
2028	0	14,258	0	0	0	0	**0**	**14,258**
2029	0	14,258	0	3,565	0	3,565	**0**	**21,387**
2030	0	14,258	0	7,129	0	7,129	**0**	**28,516**
2031	0	14,258	0	7,129	0	7,129	**0**	**28,516**
2032	0	14,258	0	7,129	0	7,129	**0**	**28,516**
2033	0	14,258	0	7,129	0	7,129	**0**	**28,516**
2034 +	0	14,258	0	7,129	0	7,129	**0**	**28,516**

2.9 Refined Oil Products - Uintah Advantage

Uintah Advantage is the name of an organization seeking to develop a small refinery within the Uinta Basin. At 40,000 bpd, that refinery would represent a significant growth opportunity for crude oil producers in the Basin, approximately a 50% increase over the 80,000 bpd now sent on average between Basin producers and Salt Lake City refineries. But, in contrast with the volume to Salt Lake City refineries, the Uintah Advantage refinery would provide a destination to which Basin crude oil producers always would enjoy a significant, competitive, geographic advantage and, presumably, WTI pricing or close to

it, as opposed to the heavy WTI discounts historically imposed by the Salt Lake City area refineries on Uinta Basin producers of crude. Although the refinery would consume 40,000 barrels per day of Uinta oil produced locally, if built, it would not ship all of those barrels via the UBRR because approximately half of that volume would be consumed locally. So, the operation of the Uintah Advantage refinery, should it come into existence, would have the effect of limiting the volume of oil and refined oil products that would use the prospective railroad.

As a result of the above, the Lower forecast reflects the assumption that the Uintah Advantage refinery does come into existence and consumes 40,000 barrels per day beginning in 2022 and continuing throughout the forecast period. That consumption translates into 11,977 carloads of refined products assumed to be moved in roughly equal proportion to Houston, TX and Oakland, CA by rail through the year 2024, which date constitutes the assumed conclusion of Phase 1 of that project. Phase 2 of that project is assumed to commence in 2025 but results in a smaller volume of annual carloads, 8,555, destined to the same locations but based on an assumed upgrading of the refinery to the production of higher-value commodities, which upgrade would have the effect of reducing the volume of products shipped by rail. In contrast, counterintuitively, the Higher forecast reflects the assumption that the local refinery is not built and a higher volume of locally-based crude oil production, therefore, is available to traverse the prospective railroad, equating to 22,812 carloads annually.

The application of these assumptions results in the following carload volumes and prospective destinations in the Higher and Lower forecasts.

Table 2-5
Refined Oil Products Carload Volumes, 2022-2042

	Oakland, CA		Houston, TX		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	5,988	0	5,988	0	**11,977**	**0**
2023	5,988	0	5,988	0	**11,977**	**0**
2024	5,988	0	5,988	0	**11,977**	**0**
2025	4,277	0	4,277	0	**8,555**	**0**
2026	4,277	0	4,277	0	**8,555**	**0**
2027	4,277	0	4,277	0	**8,555**	**0**
2028	4,277	0	4,277	0	**8,555**	**0**
2029	4,277	0	4,277	0	**8,555**	**0**
2030	4,277	0	4,277	0	**8,555**	**0**
2031	4,277	0	4,277	0	**8,555**	**0**
2032	4,277	0	4,277	0	**8,555**	**0**
2033	4,277	0	4,277	0	**8,555**	**0**
2034 +	4,277	0	4,277	0	**8,555**	**0**

2.10 Sodium Bicarbonate

The Piceance Basin, somewhat north of Rifle, CO, contains North America's only known, significant deposits of nahcolite – a soft, colorless or white carbonate mineral with the composition of sodium bicarbonate. Sodium bicarbonate is used in a variety of products and industries including food and baking, personal care, pharmaceutical, animal nutrition, agriculture, pool and water treatment and industrial markets. Natural Soda, the second largest producer of sodium bicarbonate in North America, is currently the only company taking advantage of this world class resource as its major competitor uses non-natural ingredients. Natural Soda's operation is a sophisticated, reliable and efficient process for recovering pure, naturally-occurring, sodium bicarbonate from the largest known nahcolite deposits in the world. The plant's location could provide easy access to the prospective railroad via a to-be-constructed spur in the event economic and other factors resulted in the construction of the prospective railroad on an alignment that traversed the Piceance Creek Basin. The plant's production today is shipped both in bulk and in bags. All of the bagged materials move by truck. In contrast, the bulk material moves both via truck and truck-to-rail. It is important to note that this potential movement is the only shipment of significant size that has been identified to date that would originate or terminate on the prospective railroad in Colorado, although additional rail users may be identified once the route alignment issue is settled.

The Lower forecast reflects the assumption that the selected alignment of the subject railroad is too far from the plant to make service by the prospective railroad competitive, which would certainly be the case if the Craig alignment were chosen. In contrast, currently bulk material is moved by rail via a transload operation in Rifle, Colorado, which was served by Union Pacific prior to its acquisition of Southern Pacific. So, in addition to replacing higher truck costs with a direct-to-rail shipment at its plant, Natural Soda might benefit from the establishment of the prospective railroad, assuming that the railroad gained access directly also to BNSF at or near Rifle. That said, RLBA's Higher forecast employs the same number of carloads, approximately 600 annually, regardless of year, because even though the vast majority of current shipments are to markets distant enough from Colorado to make rail service competitive, a combination of customer convenience, shipment size and customer preference for bagged materials limits the upside potential to increase traffic from this rail shipper on the prospective rail line. The Higher forecast could prove to be too conservative in the long run given that the plant's production capability was doubled as recently as 2013. However, the executive interviewed by RLBA at Natural Soda indicated that the company did not have any plans under consideration to expand production further and, therefore, it was deemed prudent to not increase the carload forecast in the out years of this forecast.

The application of these assumptions results in the following carload volumes and prospective destinations in the Higher and Lower forecasts.

Table 2-6
Sodium Bicarbonate Carload Volumes, 2022-2042

	Los Angeles, CA		Houston, TX		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	0	300	0	300	**0**	**600**
2023	0	300	0	300	**0**	**600**
2024	0	300	0	300	**0**	**600**
2025	0	300	0	300	**0**	**600**
2026	0	300	0	300	**0**	**600**
2027	0	300	0	300	**0**	**600**
2028	0	300	0	300	**0**	**600**
2029	0	300	0	300	**0**	**600**
2030	0	300	0	300	**0**	**600**
2031	0	300	0	300	**0**	**600**
2032	0	300	0	300	**0**	**600**
2033	0	300	0	300	**0**	**600**
2034 +	0	300	0	300	**0**	**600**

2.11 Fly Ash - Enefit

As discussed above in the context of Shale Oil - Enefit, plans are proceeding to finish the permitting and commence construction of an shale oil mining operation in the Uinta Basin. Were the mining to commence along the scale of operations currently contemplated, the most valuable and voluminous commodity to be produced would be the shale oil described above. However, the mining operation also would yield a significant volume of fly ash as a byproduct of the mining of the shale. Consistent with the treatment of Shale Oil – Enefit, above, in its Lower forecast volumes, RLBA assumed that the plant would not commence operations during the forecast period. And, therefore, no rail carloads of Enefit fly ash are shown. In contrast, in its Higher forecast, RLBA forecasts that 125 carloads of fly ash per year will be transported on the subject railroad during the first phase of the project, specifically, commencing in 2026 and ramping up through 2028. That forecast also reflects the assumption that that volume will double in 2029, commensurate with the assumed startup of the second phase of that operation. Destinations to which that fly ash might be delivered have not been identified, but are believed to be sufficiently distant from the Uinta Basin to make use of the prospective railroad economic.

2.12 Fly Ash - Deseret Power Electric Cooperative

Deseret Power Electric Cooperative (DPEC) provides electrical power to industries and residents in the Uinta Basin and parts of five states. Deseret's primary generating resource is the Bonanza Power Plant. As previously discussed, the Bonanza Power Plant is the western terminus and sole destination of Deseret Power Railroad (DPR), the right-of-way of which is presumed would be largely integrated into the UBRR. The amount of electricity generated by the power plant is relatively constant from year to year al-

though there are variations from the norm. As previously discussed in the context of the Fly Ash - Enefit carload forecast, generation of power from the use of coal results in a substantial volume of fly ash which today moves by truck from the plant to the Salt Lake City area, where it is transloaded to rail and moved in roughly equal proportion to markets in the Sacramento and Houston metropolitan areas. Historical volumes average approximately 1,000 carloads per year. This volume is set to continue until at least until 2030, by which time, as the result of an agreement between DPEC and the Environmental Protection Agency, the Bonanza Plant must install specific emission control equipment to continue operating. At this point, it is unknown if DPEC will install said equipment or decide, instead, to decommission the plant.

Beyond fly ash, DPR management suggested that, if built, the UBRR could serve to meet additional future transportation needs, including inbound heavy equipment and both periodic inbound (to the Bonanza Power Plant) and outbound (from the Deserado Mine) coal shipments. As a result, the carload forecasts employed in this analysis may potentially understate potential traffic volume available to the subject railroad associated with this prospective rail customer, although such uses are both too speculative and too far in the future to be appropriate to include in this study.

The application of these assumptions results in the following carload volumes and prospective destinations in the Higher and Lower forecasts.

Table 2-7
Fly Ash Carload Volumes, 2022-2042

	TBD		Oakland, CA		Sacramento, CA		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	0	0	500	500	500	500	**1,000**	**1,000**
2023	0	0	500	500	500	500	**1,000**	**1,000**
2024	0	0	500	500	500	500	**1,000**	**1,000**
2025	0	0	500	500	500	500	**1,000**	**1,000**
2026	0	125	500	500	500	500	**1,000**	**1,125**
2027	0	125	500	500	500	500	**1,000**	**1,125**
2028	0	188	500	500	500	500	**1,000**	**1,188**
2029	0	250	500	500	500	500	**1,000**	**1,250**
2030	0	250	500	500	500	500	**1,000**	**1,250**
2031	0	250	500	500	500	500	**1,000**	**1,250**
2032	0	250	500	500	500	500	**1,000**	**1,250**
2033	0	250	500	500	500	500	**1,000**	**1,250**
2034 +	0	250	500	500	500	500	**1,000**	**1,250**

2.13 Gilsonite

Gilsonite, also known as "uintahite," "asphaltum" and asphaltite, is a naturally occurring solid hydrocarbon and an extremely pure form of asphalt (or bitumen) with a relatively high melting temperature which, given its unique chemical properties and physical characteristics, gilsonite is particularly valuable in improving the performance of many critical materials and applications. Although the substance has been historically mined and its only large-scale production occurs in the Uinta Basin of Utah and Colo-

rado, resources are being discovered and mined more recently in other countries such as Colombia and Iran.

While the price of oil stimulates the production of gilsonite in any given year, ironically, oil production volumes in the Uinta Basin do not affect gilsonite production because it is not used in the Basin's oil production. Gilsonite is distributed to just about every state in the U.S., but the prospective railroad primarily would be involved in the export of gilsonite, with about equal volumes passing through Oakland, CA and Houston, TX. RLBA employed a constant volume of 400 carloads annually in its Lower case forecast, commencing immediately and twice that amount, 800 annual carloads, in every year of its Higher forecast. Those forecast volumes are in line with average relatively poor and good years, respectively.

The application of these assumptions results in the following carload volumes and prospective destinations in the Higher and Lower forecasts.

Table 2-8
Gilsonite Carload Volumes, 2022-2042

	Oakland, CA		Houston, TX		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	200	400	200	400	**400**	**800**
2023	200	400	200	400	**400**	**800**
2024	200	400	200	400	**400**	**800**
2025	200	400	200	400	**400**	**800**
2026	200	400	200	400	**400**	**800**
2027	200	400	200	400	**400**	**800**
2028	200	400	200	400	**400**	**800**
2029	200	400	200	400	**400**	**800**
2030	200	400	200	400	**400**	**800**
2031	200	400	200	400	**400**	**800**
2032	200	400	200	400	**400**	**800**
2033	200	400	200	400	**400**	**800**
2034 +	200	400	200	400	**400**	**800**

2.14 Inbound Commodities

2.15 Frac Sand

Frac sand, particularly inbound from Wisconsin and Illinois, to support the development of oil and gas wells, is the largest inbound commodity identified thus far, and while it is not as significant as outbound crude oil to the potential viability of the subject railroad, it is projected to generate more carloads, by far, than any other commodity on the prospective railroad except crude oil.

The volume of frac sand and equated projected carloads are related to the total amount of oil produced

in the Uinta Basin forecast in a given year, not just the amount of crude oil or refined oil products that moves over the prospective railroad. Specifically, it is related to the projected oil production that underlies the Lower and Higher carload forecasts, namely 225,000 and 350,000 bpd, respectively, and grows proportionately as projected volumes ramp up to those amounts. Frac sand volumes in the Higher forecast, increase from 18,667 carloads in 2022 to 56,000 in 2024, constituting the ramp up period, before increasing by 2% per annum after that to 68,264 in 2034 and beyond. Similarly, frac sand volumes in the Lower forecast increase from 15,975 carloads in 2022 to 27,000 in 2026, constituting the ramp up period, before increasing by 1% per annum after that to 29,237 in 2034 and beyond.

Not captured in either the Lower or Higher carload forecasts are the volumes of frac sand which could be shipped via the UBRR in the event that gas exploration increased in the Uinta Basin. At this time, the prospect of such exploration remains too speculative to advance any volume forecast. However, it should be noted that if said exploration did occur, the carload volumes of frac sand advanced in the Higher forecast could potentially be understated, perhaps even significantly.

The application of these assumptions results in the following carload volumes and prospective originations in the Higher and Lower forecasts.

Table 2-9
Frac Sand Carload Volumes, 2022-2042

	La Crosse, WI		Chicago, IL		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	7,988	9,333	7,988	9,333	**15,975**	**18,667**
2023	9,563	18,667	9,563	18,667	**19,125**	**37,333**
2024	11,138	28,000	11,138	28,000	**22,275**	**56,000**
2025	12,713	28,560	12,713	28,560	**25,425**	**57,120**
2026	13,500	29,131	13,500	29,131	**27,000**	**58,262**
2027	13,635	29,714	13,635	29,714	**27,270**	**59,428**
2028	13,771	30,308	13,771	30,308	**27,543**	**60,616**
2029	13,909	30,914	13,909	30,914	**27,818**	**61,829**
2030	14,048	31,533	14,048	31,533	**28,096**	**63,065**
2031	14,189	32,163	14,189	32,163	**28,377**	**64,326**
2032	14,331	32,806	14,331	32,806	**28,661**	**65,613**
2033	14,474	33,463	14,474	33,463	**28,948**	**66,925**
2034 +	14,619	34,132	14,619	34,132	**29,237**	**68,264**

2.16 Steel Pipe

Steel pipe and other tubular products are significant and necessary contributors to modern oil production methods. Today, Colorado Tube and Pipe (CTAP) is the dominant supplier of such products into the Uinta Basin. Based on a telephone interview with its Senior Vice President, Operations, Quality Assurance and Technical Sales, RLBA believes that a very large share of inbound tubular products would be transported there via the UBRR, were it built. In fact, the individual interviewed volunteered that of the 12 supply yards in 8 states for which he is responsible, Vernal, UT (located in the Uinta Basin) is the only yard that is not rail-served. Instead, the Uinta Basin is generally supplied by yards CTAP operates in

Craig and Rifle, Colorado, exactly the two endpoints being studied in this report as possible junctions of the prospective railroad with one or more major railroads. CTAP would be strongly inclined to move the maximum amount of its products possible via the prospective railroad for a variety of reasons including economics. However, that would not translate into all of its volume due to customer preferences and the inability, so far, of the rail industry to provide sufficiently reliable service to make CTAP comfortable that its customers will not suffer stock outs due to failed deliveries by rail.

As was the case with several of the above-discussed commodities, the volume of tubular goods forecast to move via the UBRR is related to the total amount of oil production in the Uinta Basin.. In the Higher case, the forecast equates to 9,100 carloads in 2022, rising steadily to 12,600 in 2024 and then more modestly to 15,359 carloads in 2034 and beyond. In the Lower case, the forecast equates to 4,792 carloads in 2022, rising steadily to 8,100 in 2026 and then more modestly to 8,771 carloads in 2034 and beyond.

The application of these assumptions results in the following carload volumes and prospective originations in the Higher and Lower forecasts.

Table 2-10
Steel Pipe Carload Volumes, 2022-2042

	Birmingham, AL		Gary, IN		Total	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	2,396	4,550	2,396	4,550	**4,792**	**9,100**
2023	2,869	5,945	2,869	5,945	**5,738**	**11,890**
2024	3,341	6,300	3,341	6,300	**6,682**	**12,600**
2025	3,814	6,426	3,814	6,426	**7,628**	**12,852**
2026	4,050	6,555	4,050	6,555	**8,100**	**13,109**
2027	4,091	6,686	4,091	6,686	**8,181**	**13,371**
2028	4,131	6,819	4,131	6,819	**8,263**	**13,639**
2029	4,173	6,956	4,173	6,956	**8,345**	**13,911**
2030	4,214	7,095	4,214	7,095	**8,429**	**14,190**
2031	4,257	7,237	4,257	7,237	**8,513**	**14,473**
2032	4,299	7,381	4,299	7,381	**8,598**	**14,763**
2033	4,342	7,529	4,342	7,529	**8,684**	**15,058**
2034 +	4,386	7,680	4,386	7,680	**8,771**	**15,359**

3.0 Approach Part 2 - Determination of Costs to Reach the National Rail Network

3.1 Summary of RLBA Approach

RLBA employed a three-step process to determine the cost to reach the national rail network, including:

1. Developing an Operating Plan Unique to Each Proposed UBRR Alignment;
2. Developing Costs Associated with Each Operating Plan for Each, Proposed UBRR Alignment and
3. Amending and Including the Initial Capital Investment to Build Each, Proposed UBRR Alignment.

3.2 Developing an Operating Plan Unique to Each Proposed UBRR Alignment

RLBA developed two operating plans in connection with each of the three, proposed alignments; one reflecting the Higher forecast volumes and another reflecting the Lower forecast volumes. These operating plans primarily reflected consideration of: 1) the volumes of freight forecasted to be shipped both inbound to and outbound from the Uinta Basin; and 2) the physical characteristics of the alignment. The operating plans were critical to the determination of the manpower, material, equipment and physical plants required to adequately support the movement of the forecasted volumes over the railroad. The specifics of each operating plan are defined in the following sections.

3.3 Developing Costs Associated with Each Operating Plan for Each, Proposed UBRR Alignment

The manpower, material, equipment and physical plant requirements of each operating plan were putt into RLBA's short line costing model. This costing model draws on real world costing data drawn from proprietary databases maintained by RLBA to provide highly accurate cost estimations. The RLBA costing model considers six major inputs: the four major operating expense cost centers associated with railroad operations and capital expenses regarding Maintenance of Equipment and Maintenance of Way. For purposes of this study, RLBA defines each of these inputs as follows:

1. **Transportation** - Alternatively known as the as the Train and Engine (T&E) Department on a railroad, encompasses the manpower and material necessary to operate trains over the railroad;

2. **Equipment** - Alternatively known as the Mechanical Department, encompasses the manpower and materials required to maintain the rolling stock of a railroad. Equipment expenses captured in operating costs are considered "routine maintenance" costs and encompass the day-to-day upkeep and repair activity required to ensure that equipment is available to support railroad operations;

3. **Maintenance of Way (MOW)** - Alternatively known as the Engineering Department, encompasses the manpower and materials to maintain the physical plant of a railroad (i.e., the track structure, grading, bridges, road crossings and signals). MOW expenses captured in operating costs are considered "routine maintenance" costs and encompass the day-to-day upkeep and repair activity required to ensure that the track structure is available to support railroad operations;

4. **General and Administrative** - Spans several departments of most railroads, and encompasses the expenses other than those attributed to train operations or maintenance of a railroad's equipment or physical plant. These activities generally include 'back office' functions and the executives of the railroad and other departments such as Human Resources, Marketing, Legal etc.;

5. **Equipment Capital Expense (Capex)** - Also referred to as "Program Maintenance" encompasses the expenses to acquire railroad equipment (sometimes referred to as "Expansion Capital Expense") and the expenses to perform major overhauls or repairs to same with the goal of extend-

ing the useful life of the equipment, or the outright replacement of existing equipment (sometimes referred to as "Maintenance Capital Expense") and

6. **Maintenance of Way (MOW) Capital Expense (Capex)** - Also referred to as "Program Maintenance" encompasses the expenses to build new railroad right of way and track structure and the expenses to preform major renewal projects with the goal of extending the useful life of the track structure or the outright replacement of existing railroad right of way and track structure (sometimes referred to as "Expansion Capital Expense").

3.4 Amending and Including the Initial Capital Investment to Build Each Proposed UBRR Alignment

Conceptual engineering costs to construct each of the three, proposed UBRR alignments prepared by Jones & DeMille were integrated into the cost model. RLBA understands that: 1) Jones & DeMille was only engaged to prepare 'high level' estimates regarding the level of effort and associated cost to construct the three rail alignments; 2) information regarding the physical characteristics of the three proposed rail alignments through Colorado was largely based on a 2001 DMJM Harris Study; and 3) limited information was prepared regarding the physical characteristics of the shared alignment through Utah.

The Jones & DeMille cost estimates reflect the construction of a single track railroad, with no additional support infrastructure. As such, RLBA included additional costs to reflect, as necessary, additional infrastructure not captured in the conceptual costs developed by Jones & DeMille, including side and yard tracks, signal and train traffic control systems and maintenance facilities. The specific additional costs added by RLBA are defined in the following sections.

3.5 Comment Regarding Assumptions Regarding the Physical Characteristics of the Railroad

It is important to note that the physical characteristics of a specific railroad have wide reaching implications as to the level of effort and associated cost to both operate and maintain any railroad. As prepared, the Jones & DeMille conceptual engineering plans included limited, if any, specific physical characteristics regarding the three potential rail alignments. In the absence of specific information regarding the physical characteristics of the potential UBRR alignments, RLBA professionals were required to employ a significant amount of professional judgment and estimation in developing the costing information required by this assignment. Because of the these limitations in the conceptual level engineering data, RLBA stresses that values advanced in this report are to be considered high level estimations; more accurate operating and maintenance cost estimations would require a much more detailed understanding of the physical characteristics and profile of the railroad.

3.6 Consideration of Institutional Arrangements

To determine a more exact estimate of the costs associated with the UBRR, RLBA considered three discrete institutional arrangements by which service could be provided on the UBRR:

1. A public entity, or a consortium of public entities, constructs the UBRR and leases or enters into an operating agreement regarding the new railroad with UP or BNSF to operate;

2. A public entity, or a consortium of public entities constructs the UBRR and leases or enters into an operating agreement regarding the new railroad with a short line to operate; and

3. A public entity, or a consortium of public entities, constructs the UBRR and creates a new railroad entity, thus operating the line itself.

These three arrangements represent the most likely methods by which the UBRR would operate, based on current standards and trends in the industry. It is important to note that in all three arrangements considered by RLBA, RLBA assumed that construction of the railroad would be the responsibility of SCIC, another public entity, or a consortium of public entities. While private/public partnerships ("3Ps") are not unprecedented in the freight rail industry, there has never been such a partnership approaching the size and scope of the UBRR. Furthermore, given the generally conservative nature of the rail freight industry, RLBA believes any railroad which may eventually service the line has relatively little incentive to invest in the construction of the line, especially given the high associated capital costs projected and lack of current production levels sufficient to justify construction.

The following describes the pros and cons of each railroad institutional arrangement.

1. **Public entity(s) constructs the UBRR and leases or enters into operating agreement with UP or BNSF** - The most recognizable advantage of leasing the line directly to UP or BNSF is that such an agreement would eliminate the need for an additional railroad to transport freight to and from either Rifle or Craig, resulting in possible time and cost savings realized by both the carrier and its customers. Conversely, there are two significant problems with leasing the line to UP or BNSF. First, due to the significant size of the two railroads, the quality of service may not be up to that delivered by a much smaller customer-focused short line. Second, like all the major Class One railroads, UP and BNSF have continually emphasized investment in major, high-capacity mainlines over the last few decades, while at the same time aggressively reducing the number of branch lines along their systems , either by divesting operations to short lines or outright abandonment. As much was confirmed during conference calls with BNSF, during which representatives from the railroad stated their preference to service the UBRR via interchange with a Class Two or Class Three operator at Rifle;

2. **Public entity(s) constructs the UBRR and leases or enters into operating agreement with a short line operator** - The pros and cons of entering into an operating agreement with a short line operator are essentially the inverse of those associated with UP or BNSF operating the line. The hallmark of even the largest short line holding companies is customer service. Most short lines are headquartered along the rights-of-way they own or operate, allowing direct access to railroad managers by local customers and vice versa. Short lines are generally much more flexible to work with regarding such key commercial terms as service, billing and operating agreements, often working one-on-one with customers to tailor solutions to meet their individual needs. Additionally, many Class Ones, including UP and BNSF, enjoy working with short lines, to feed the larger

railroad traffic while leaving the more labor and cost intensive "last miles" to short line operators. The disadvantages of a short line operator in this situation are the potential loss of time and money associated with another party handing traffic between the Uinta Basin and either Rifle or Craig, although the above-mentioned flexibility and high level of customer service may more than offset these potential losses. As such, RLBA considers these disadvantages to be minimal given the improved customer service and general direction in which the industry has been heading regarding the role of short lines; and

3. **Public entity(s) constructs the UBRR and creates and operates a new railroad** - The most obvious advantage of this arrangement is that the public entity that built the line would enjoy total control over railroad operations and, as such, could ensure the railroad provided near optimal service to meet the needs of its customers. There are, however, several serious negative aspects to consider as well. First, acquiring the necessary manpower and equipment to operate the railroad would dramatically increase the initial capital investment, as well as expose the subject public entity(s) to additional financial and liability considerations. Secondly, significant effort would have to be made by the subject public entity(s) to assemble an experienced staff to stand up railroad operations. Both these issues would result in the subject public entity(s) committing huge resources to issues that are most likely well outside respective scope(s) and mission(s).

Table 3-1
Third Party Operator Profit Margin, 2022-2042

	Rifle via Meeker		Rifle via Piceance		Craig	
	Lower	Higher	Lower	Higher	Lower	Higher
2022	$ 2,561,259	$ 4,800,159	$ 2,586,269	$ 4,898,870	$ 2,181,271	$ 3,874,205
2023	$ 3,232,384	$ 7,016,664	$ 3,269,173	$ 7,184,821	$ 2,666,017	$ 5,483,023
2024	$ 4,425,621	$ 9,243,583	$ 4,482,977	$ 9,478,971	$ 3,527,726	$ 7,120,129
2025	$ 5,376,229	$ 9,392,034	$ 5,450,711	$ 9,632,130	$ 4,242,166	$ 7,230,925
2026	$ 5,566,345	$ 9,970,764	$ 5,644,512	$ 10,230,849	$ 4,381,507	$ 7,696,288
2027	$ 5,615,814	$ 10,197,078	$ 5,694,709	$ 10,462,061	$ 4,420,963	$ 7,811,560
2028	$ 5,665,926	$ 10,356,534	$ 5,745,556	$ 10,626,512	$ 4,460,961	$ 7,930,864
2029	$ 5,716,688	$ 10,730,862	$ 5,797,061	$ 11,013,530	$ 4,525,465	$ 8,203,000
2030	$ 5,768,112	$ 11,250,245	$ 5,849,235	$ 11,545,705	$ 4,566,573	$ 8,595,611
2031	$ 5,844,161	$ 11,417,426	$ 5,926,042	$ 11,718,187	$ 4,608,249	$ 8,720,385
2032	$ 5,896,935	$ 11,587,950	$ 5,979,582	$ 11,894,119	$ 4,650,501	$ 8,847,654
2033	$ 5,950,400	$ 11,761,884	$ 6,033,820	$ 12,073,569	$ 4,693,339	$ 8,977,469
2034 +	$ 6,004,566	$ 11,939,297	$ 6,088,767	$ 12,256,609	$ 4,736,772	$ 9,109,880

While all three methods have merits, RLBA believes the most practical option in this instance is to have a public entity(s) enter into an operating agreement or lease with an established short line operator. A short line operator should provide the 'personalized' servicing of Uinta Basin customers. This would allow the public entity to focus on its core function and mission with only an oversight role over rail operations, such as receiving regular reports and holding regular meetings with the carrier's management. For proposes of this cost comparison exercise, RLBA assumed that all rail operations would be conducted by a third party, contract operator. Furthermore, it was assumed that the third party operator would expect to

realize a 15% profit margin above the operational expense associated with the operation of the railroad.

3.7 Explanation of Methodologies Used in Determining Costs to Reach the National Rail Network

The following section provides a synopsis of the methodologies employed by RLBA to determine the cost to reach the national rail system.

3.8 Operating Plan

In all three alignments, RLBA assumed that railroad operations on the UBRR were based at the western end of the railroad at either Myton or Leland Bench, hereafter, the "West End Yard." Facilities at the western end of the railroad would include the UBRR's primary yard facility, maintenance facilities and administrative offices. The only other major facilities on the railroad are located at the eastern end of the line at either Rifle or Craig, CO, respectively, hereafter the "East End Yard." Facilities at the eastern end would include a second yard to facilitate interchange with UP and/or BNSF and a minor maintenance facility.

With the expectation of sodium bicarbonate produced by Natural Soda at a location north of Rifle (only in the Higher forecast scenarios) and fly ash produced at the Bonanza Power Plant, all outbound traffic on the railroad was assumed to originate at the West End Yard, where commodities were assumed to be loaded onto railcars via privately owned and operated transloading facilities located adjacent to West End Yard. Due to the preliminary status of the UBRR project, no information regarding the location of potential shipper's facilities was available to consider. The cost to transport commodities to the transloading facilities and load on railcars is not reflected in this study. Conversely, RLBA further assumed that all inbound traffic on the railroad would be received via interchange at the East End Yard and transloaded off of rail at West End Yard for final disposition. Again, the cost of transporting inbound commodities to their final destinations, likewise, is not reflected in this study.

Because the vast majority of rail traffic is either loaded or unloaded at West End Yard and interchanged or received from interchange at East End Yard, operations on the UBRR are relatively simple. The vast majority of trains were assumed to traverse the entire length of the line. Train crews are assumed based out of West End Yard. Due to Federal law limiting the number of hours a crew member can work, it is assumed that train crews spend the night at a local hotel near East End Yard before returning back to their base on an inbound train and vice versa.

3.9 Transportation

Transportation costs primarily consist of two, major components, labor and fuel. To determine these costs on the UBRR, RLBA developed a per-train cost associated with each of the most prominent train types on the UBRR. Because of the simplistic nature of UBRR operations, trains on the line can be categorized into four types:

1. **Loaded Unit Trains** - The majority of trains on the UBRR are unit trains – or trains consisting entirely of a single commodity loaded at a single location and destined to a single location, thus

resulting in significant cost and time savings. There are four types of unit trains on the UBRR: 1) outbound, loaded unit oil trains (consisting of both crude oil and shale oil carloads); 2) outbound, loaded unit refined oil product trains (only in Lower forecast); 3) inbound, loaded unit frac sand trains; and 4) inbound, loaded unit steel pipe trains. Side track length on the UP Central Corridor between Salt Lake City and Denver limits trains on the UBRR to 6,200 feet in length. This makes the maximum train length on the UBRR 95 cars. To maximize equipment utilization and efficiency, for the purposes of this study, RLBA assumed that outbound, unit crude trains were held at West End Yard until a full, 95-car train was ready to interchange with the UBRR's Class One partner.

2. **Empty Unit Trains** - Because unit trains are designed to handle a single commodity, the majority of unit trains, including those on the UBRR, would return to their point of origin empty, at which point they are assumed to be reloaded with this commodity. Because of the simplistic nature of the UBRR's operations, RLBA assumed that every loaded unit train resulted in a corresponding empty unit train, consisting of the same number of cars. The four types of empty unit trains on the UBRR include: 1) inbound, empty unit oil trains; 2) inbound, empty unit refined oil product trains (Lower forecast only); 3) outbound, empty unit frac sand trains and 4) outbound, empty unit steel pipe trains.

3. **Outbound, Loaded, Manifest Trains** - As opposed to unit trains, manifest trains consist of cars containing a variety of commodities and freight car types, from one or more origins, bound to a number of different destinations. These cars are brought from their various origins to a yard and assembled into a single manifest train. Once a manifest train reaches its destination yard, the cars are disassembled and delivered to their respective destinations. On the UBRR, manifest trains handle commodities which do not project enough volume to warrant dedicated, unit trains, including: 1) outbound sodium bicarbonate, 2) outbound fly ash and 3) outbound gilsonite. To maximize equipment utilization and efficiency, for the purposes of this study, RLBA assumed that manifest trains were held at West End Yard until a full, 95-cartrain was ready to interchange with the UBRR's Class One partner. Like unit trains, outside of yard facilities manifest trains are ultimately transiting from one terminus of the UBRR to the other. However, unlike unit trains, manifest trains make periodic, stops to pick up loads of fly ash from the Bonanza Power Plant in Bonanza, UT, as well as loads of sodium bicarbonate from Natural Soda. Additionally, outbound, loaded manifest trains require additional time in West End Yard to collect the various cars and assemble them into a single train consisting of bunches of cars "blocked" by final destination region. At the East End interchange, the train was assumed delivered to the UBRR's Class One partner in the same manner as a unit train.

4. **Inbound, Empty, Manifest Trains** - While the nature of manifest traffic means that most such trains are carrying both loaded and empty railcars, all inbound traffic on the UBRR is handled by unit trains (frac sand and steel pipe). As such, the only manifest traffic on the UBRR consists of empty cars returning to West End Yard to be reloaded. Consistent with its treatment of empty unit trains, RLBA assumed that every outbound loaded manifest train resulted in a corresponding inbound empty manifest train. At the East End interchange, the train was assumed to be received from the UBRR's Class One partners in the same manner as a unit train. However, these trains

require additional time once arriving at West End Yard to disassemble the train and deliver the cars to specific locations to be reloaded.

Table 3-2
UBRR Number of Trains by Type, 2022-2042

	Oil Unit (Crude)		Oil Unit (Shale Oil)		Refined Oil Unit		Frac Sand Unit	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	78	683	0	0	126	0	168	196
2023	234	1,144	0	0	126	0	201	393
2024	538	1,604	0	0	126	0	234	589
2025	821	1,636	0	0	90	0	268	601
2026	861	1,669	0	150	90	0	284	613
2027	870	1,702	0	150	90	0	287	626
2028	879	1,736	0	150	90	0	290	638
2029	888	1,771	0	225	90	0	293	651
2030	896	1,806	0	300	90	0	296	664
2031	905	1,842	0	300	90	0	299	677
2032	914	1,879	0	300	90	0	302	691
2033	924	1,917	0	300	90	0	305	704
2034 +	933	1,955	0	300	90	0	308	719

	Steel Unit		Empty Unit		Loaded Manifest		Empty Manifest	
Year	Lower	Higher	Lower	Higher	Lower	Higher	Lower	Higher
2022	50	96	423	975	15	25	15	25
2023	60	125	622	1,662	15	25	15	25
2024	70	133	969	2,326	15	25	15	25
2025	80	135	1,259	2,373	15	25	15	25
2026	85	138	1,321	2,570	15	27	15	27
2027	86	141	1,333	2,619	15	27	15	27
2028	87	144	1,346	2,668	15	27	15	27
2029	88	146	1,358	2,793	15	28	15	28
2030	89	149	1,371	2,920	15	28	15	28
2031	90	152	1,384	2,972	15	28	15	28
2032	91	155	1,397	3,026	15	28	15	28
2033	91	159	1,410	3,080	15	28	15	28
2034 +	92	162	1,423	3,136	15	28	15	28

To determine the per train cost of each of these four types of trains, RLBA: 1) developed train physical characteristics; 2) determined unit costs of labor and fuel; 3) completed rudimentary performance simulations to determine train performance; and 4) applied unit costs based on train performance.

RLBA's train performance calculations were based on the conceptual level engineering data provided by Jones & DeMille, which, due to the 'high level' nature of the data, required a significant amount of professional estimation by RLBA professionals. Because of the aforementioned limitation in the conceptual level engineering data, RLBA stresses that these train performance and resulting per-train cost amounts are to be considered high level estimates. More accurate train costs would require a much more detailed understanding of the physical characteristics and profile of the railroad.

Table 3-3
Per Train Cost by Train Type on the UBRR

Rail Alignment	Train Type	Fuel Cost	Labor Cost	Total
Rifle via Meeker	Loaded Unit	$ 12,624	$ 844	**$ 13,468**
	Empty Unit	$ 4,540	$ 804	**$ 5,344**
	Loaded Manifest	$ 12,629	$ 1,266	**$ 13,895**
	Empty Manifest	$ 4,545	$ 844	**$ 5,389**
Rifle via Piceance	Loaded Unit	$ 13,019	$ 844	**$ 13,863**
	Empty Unit	$ 4,540	$ 804	**$ 5,344**
	Loaded Manifest	$ 12,629	$ 1,266	**$ 13,895**
	Empty Manifest	$ 4,545	$ 844	**$ 5,389**
Craig	Loaded Unit	$ 8,813	$ 844	**$ 9,657**
	Empty Unit	$ 2,910	$ 804	**$ 3,714**
	Loaded Manifest	$ 8,068	$ 1,161	**$ 9,229**
	Empty Manifest	$ 3,510	$ 844	**$ 4,354**

3.10 Equipment

RLBA assumed that all railroad cars traversing the UBRR are privately owned or leased by shippers and, as such, no railroad cars beyond those required to support railroad maintenance are owned or operated by the carrier. The cost to lease railcars borne by shippers was included as a separate line item outside of the short line model but included in the transportation option cost comparison detailed in section 4.6 of this report.

RLBA assumed that the UBRR owns, operates and maintains its own locomotives on all trains operated over the railroad. UBRR locomotives on outbound trains were assumed to be removed at East End Yard and attached to inbound trains to complete the return trip to West End Yard. Due to the scale of UBRR operations, RLBA elected to assume that the UBRR provides its own locomotives. It should be noted that an alternative arrangement known as "run-through power," in which the Class One railroad interchanging with a short line railroad provides its locomotive to said short line at a price, is commonly employed and also could be realistically employed in the situation of the UBRR as it improves locomotive utilization, reduces costs and improves service.

RLBA further assumed that the main locomotive on the UBRR are GE ES44AC locomotives, built new for the UBRR, supplemented by rebuilt, EMD SD40-3 locomotives. The ES44AC is a 4,400 horsepower locomotive commonly found in mainline service on major heavy haul railroads around the country, including UP and BNSF. The SD40-3 is a 3,300 horsepower upgraded version of the SD40-2 locomotive, originally built between 1972 and 1989. A highly popular and reliable locomotive, the SD40-3 is a completely rebuilt locomotive regularly assigned to secondary or back up service. Both locomotives are compliant with current environmental regulations.

Based on the aforementioned simulations performed, RLBA determined that five, ES44AC locomotives (three on the front of the train, two on the rear of the train but controlled remotely) would be required to successfully power a 95-car loaded train between West End Yard and Rifle, while four, ES44AC locomo-

tives (two on the front of the train, two on the rear of the train) would be required to successfully power a 95-car loaded train between West End Yard and Craig. While unloaded trains are significantly lighter than their loaded counterparts, to ensure that locomotive utilization is maximized, all the locomotives used on a loaded train were assumed by RLBA to return on the accompanying empty train. In such cases on empty trains to/from Rifle, three locomotives are required to power the train over the railroad, while the other two locomotives are hauled dead in tow ("DIT"). On empty trains to/from Craig, two locomotives are required to power the train over the railroad, while the other two locomotives are hauled DIT.

Table 3-4
Locomotive Requirements of the UBRR, 2022-2042

	Rifle via Meeker		Rifle via Piceance		Craig	
Year	Lower	Higher	Lower	Higher	Lower	Higher
2022	7	17	7	17	6	13
2023	11	28	11	28	9	22
2024	17	42	17	42	13	34
2025	22	42	22	42	18	34
2026	22	42	22	42	18	36
2027	22	45	22	45	18	36
2028	22	45	22	45	18	36
2029	22	45	22	45	19	36
2030	22	51	22	51	19	41
2031	23	51	23	51	19	41
2032	23	51	23	51	19	41
2033	23	51	23	51	19	41
2034 +	23	51	23	51	19	41

Locomotive maintenance costs were calculated by considering per-locomotive unit costs reported by Class One railroads. While locomotive maintenance costs are generally lower on short line railroads, equipment and operations on the UBRR more closely resemble that of a Class One mainline, and, as such, Class One costs were deemed more appropriate. RLBA used a value of $159,700 annually per unit.

3.11 Maintenance of Way

The level of routine maintenance activity required on UBRR is primarily driven by the physical condition the railroad is to be maintained to and the level of traffic expected to operate over the line. RLBA determined that the railroad should be maintained to Class 3 Track Class Standards, as defined by the Federal Railroad Administration, thus allowing for a maximum safe operating speed of 40 MPH by freight trains. While not specifically required by Class 3 Track Class Standards, RLBA also assumed that the new-build portions of the railroad would feature 136-pound continuously welded rail and concrete, cross ties, materials considered industry standards on heavily used railroads. RLBA assumed that the track on the Deseret Power Railroad portion of the line, 32 miles, which was assumed to be integrated into all three, rail alignments, would consist of the track materials currently installed, which is understood to be 136-pound continuously welded rail and wooden cross ties.

RLBA assumed that the majority of routine maintenance activities would be addressed by a full time,

MOW Department employed by the UBRR or its contractor. To adequately perform the routine maintenance activities on the UBRR as defined above, RLBA determined that a labor force of 28 employees would be required on either Rifle rail alignment and 25 employees would be required on the Craig rail alignment, assuming the Higher forecast volumes. The shorter length of the Craig alignment, and therefore, lower maintenance requirements, explains the difference in the labor requirements across the proposed rail alignments. A labor force of 22 employees would be required on either Rifle rail alignment, as well as the Craig rail alignment assuming Lower forecast volumes were realized. The lower annual carloads, and thus tonnage over the line, in the Lower forecast volumes makes a full second section gang unnecessary in those scenarios.

In addition to the maintenance activities performed by the UBRR MOW Department, RLBA assumed that certain specialty tasks and services were performed by third-party contractors on a regular basis. These services include: 1) periodic weed spraying along the right-of-way; 2) third party bridge inspection and bridge maintenance plan development and recommendations; 3) periodic ballast cleaning (ballast is a layer of crushed rock, which both stabilizes the track structure and provides proper drainage); and 4) ultrasonic rail flaw detection inspections. The outsourcing of these activities is consistent with current industry practices on a railroad of similar size and scope as the UBRR.

RLBA's estimated routine maintenance cost calculations were based on the conceptual level engineering data provided by Jones & DeMille, which, due to the 'high level' nature of such data, required a significant amount of professional estimation by RLBA professionals as well as the employment of a contingency factor. Because of such limitations in the conceptual level engineering data, RLBA stresses that these maintenance costs are to be considered high level estimations. More accurate maintenance costs would require a much more detailed understanding of the physical characteristics and profile of the railroad.

3.12 General and Administrative

Because General and Administrative (G&A) activities encompass the non-transportation aspects of a rail operation (i.e., Marketing, Law, etc.), the level of manpower associated with G&A is not directly impacted by the length of a railroad or the volume of trains operating over a railroad, as are the other major cost centers. Instead, G&A manpower is driven largely by the number of customers doing business with the railroad (marketing and accounting considerations) and the number of employees employed by the railroad (human resources). As such, RLBA determined that in the Higher forecast scenarios, the UBRR would require a G&A work force of 25 employees, regardless of alignment. In the Lower forecast scenarios, the UBRR would require a work force of 17, again, regardless of alignment.

In addition to the G&A staff, RLBA assumed that a number of specialty tasks and services were performed by third-party contractors on a regular or as-needed basis, as appropriate. These services include: 1) legal services (specifically, supporting the activity of the General Counsel's office); 2) rail accident clean-up and repair services; 3) office services; 4) train crew services, including managing efforts to contact and inform train crew members of upcoming assignments, overnight lodging at the East End Yard for crews coming off duty, and transportation to and from trains as required and 5) IT services (including both in offices and the field). The outsourcing of these activities is consistent with current industry practices on a railroad of similar size and scope as the UBRR.

3.13 Equipment Capital Expenses

RLBA assumed that new locomotives were purchased as traffic volume levels warranted. Locomotives were assumed to have a useful life of 25 years, after which they would be sold and replaced. The cost to perform major overhaul or upgrade work to all UBRR locomotives was captured in the locomotive maintenance operating cost. The only capital expense associated with equipment relates to the periodic acquisition of new locomotives as traffic volumes on the railroad demand. RLBA assumed that the capital cost of such acquisitions would be amortized over a 25-year period.

3.14 Maintenance of Way Capital Expenses

Typically, renewal programs, or program maintenance activities, are designed to be performed in an on-going, cyclical nature. Only a small portion of the railroad, on which the target material has reached the end of its useful life, is addressed during a specific program year. On a typical railroad, installed materials along a railroad are at various points along their respective useful life cycles and, therefore, renewal programs are, at least theoretically, always on-going on some portion of the railroad to replace material at the end of its useful life. Because the majority of all three rail alignments would be new-build construction (the exception being the 32 miles of the Deseret Power Railroad which RLBA assumed to be integrated into the route), and because the tonnage shipped over the line gradually increases during the ramp-up period, the physical track structure of the UBRR would require significantly less than typical renewal over the first ten years of the railroad and essentially no renewal at all on the new-build portions of the railroad over the first seven years. As a result, RLBA assumed that program maintenance of the UBRR would consist of three discrete periods, including:

1. **2022 – 2028** - during this period, RLBA assumed that program maintenance activities on UBRR operations are limited to the approximately 32 miles of line which consist of the Deseret Power Railway, which existed prior to the construction of the UBRR and, thus requires regular asset renewal. During this period the material on the rest of the railroad, which was installed new, does not require any sort of replacement program;

2. **2029 – 2031** - during this period, 1) surfacing, 2) some track replacement (starting with curved track on areas with high vertical grades, thus incurring the most wear and tear from passing trains), 3) grade crossing; and 4) turnout renewal programs begin along the entire railroad; and

3. **2032 and Beyond** - during this period, 1) cross tie, and 2) structure renewal programs begin along the entire railroad.

RLBA's program maintenance calculations were based on the conceptual level engineering data provided by Jones & DeMille, which, due to the 'high level' nature of the data, required a significant amount of professional estimation by RLBA professionals. Because of limitations in the conceptual level engineering data, RLBA stresses that these maintenance costs are to be considered high level estimates. More accurate costs would require a much more detailed understanding of the physical characteristics and profile of the railroad.

3.15 Initial Construction Costs

Initial construction costs, as prepared by Jones & DeMille, were accepted 'as-is' by RLBA. Additionally, certain physical characteristic elements of the three, alignments developed by Jones & DeMille also were accepted by RLBA, specifically, route miles and, to some extent, the general terrain types of the three routes.

Table 3-5
Physical Characteristic Assumptions of UBRR Alignments Provided by Jones & DeMille Engineeering, Inc.

Item	Rifle via Meeker	Rifle via Piceance	Craig
Major Waterways	Green River, White River	Green River, White River	Green River
Major Road Crossings	SR-88, SR-64, SR-13	SR-88, SR-13	SR-88, SR-40
Engineering Criteria			
Terrain Type(s)	Hills, Mountains	Hills, Mountains	Flat, Hills
Flat (Miles)	6.14	6.14	6.14
Rolling Hills (Miles)	97.96	83.96	120.75
Mountainous (Miles)	48.83	64.66	0.00
Construction Length (Miles)	152.97	154.80	126.93
OperatedLength (Miles)	183.31	185.13	157.27
Structures			
Number of Bridges	7	3	2
Length of Bridges (Feet)	2,400	1,320	1,100
Number of culverts	57	59	34
Construction Costs Estimates			
Track	$ 693,800,000	$ 715,200,000	$ 536,500,000
Bridges	$ 24,000,000	$ 13,200,000	$ 11,000,000
Culverts	$ 500,000	$ 500,000	$ 300,000
30% Contingency	$ 215,500,000	$ 218,700,000	$ 164,400,000
3% Extraction	$ 181,100,000	$ 183,800,000	$ 138,100,000
Right of Way/Easement	$ 7,600,000	$ 7,700,000	$ 6,300,000
Professional Services	$ 224,700,000	$ 228,000,000	$ 171,400,000
Total	**$ 1,347,200,000**	**$ 1,367,100,000**	**$ 1,028,000,000**

3.16 Additional Initial Construction Costs Determined by RLBA

RLBA determined that additional infrastructure items would be required to begin rail operations on the UBRR beyond the construction costs developed by Jones & DeMille, as these costs only reflected the assumption of a single track railroad. These additional items include:

1. Structures - RLBA determined instances in which bridges would be required beyond the major river crossings identified by Jones & DeMille, either over minor waterways or over physical features over which a fill would be impractical;

2. Grade Crossings - RLBA determined instances in which the alignment crossed a road at grade, with a distinction made between major, 'improved' crossings featuring active crossing protection (cross gates and bells) and minor, 'unimproved crossings, featuring passive crossing protection (warning signs only);

3. Siding and MOW Tracks - RLBA assumed that a signal-controlled, 8,000 foot siding would be constructed every 20 miles, to allow trains to pass one another. Additionally, a MOW track was constructed at each siding, to allow MOW equipment to either be stored or temporarily moved on to so that trains might pass on the main track;

4. Train Traffic Control System - RLBA assumed that train movement on the line would be governed by a Centralized Traffic Control (CTC) system, a modern automated system which allows a dispatcher to remotely control signals and switching trains, and thus, train movements, from a single location;

5. Positive Train Control (PTC) - RLBA assumed the new railroad would built with PTC, a federally mandated safety system which, given the volumes and type of traffic moving over the UBRR, would be required by law to be installed on the railroad;

6. Yard Facilities - RLBA determined an approximation of the linear footage of yard track which would be required at both ends of the railroad to temporarily store both loaded and empty trains between trips over the railroad. No effort was made to identify or determine the cost to acquire real estate underlying said facilities but, as previously stated, Uinta Advantage has indicated a willingness to provide real estate in the Leland Bench area at little or no cost to the railroad and

7. Maintenance and Office Facilities - RLBA estimated the cost to build a central facility at West End Yard, at which all locomotive maintenance and general administrative activities required to manage the entire operation would be performed. No effort was made to identify or determine the cost to acquire real estate underlying said facilities.

RLBA determined costs specific to both the Higher and Lower forecast volume scenarios. Regardless of the volume scenario, RLBA assumed that the railroad was built to handle the maximum volume forecasted under each scenario. The physical infrastructure of the railroad was not 'scaled up' to match the increasing volumes experienced during the 'ramp-up' period of the Higher and Lower forecasts. To be consistent with the initial construction cost developed by Jones & DeMille, a 30% contingency was added to construction budgets developed in connection with the above improvements regarding the additional initial construction cost determined by RLBA.

Table 3-6
Additional Initial Construction Costs Determined by RLBA

Item	Rifle via Meeker		Rifle via Piceance		Craig	
	Lower	Higher	Lower	Higher	Lower	Higher
Main Line						
Structures	$ 37,775,000	$ 37,775,000	$ 42,925,000	$ 42,925,000	$ 23,100,000	$ 23,100,000
Grade Crossings	$ 870,200	$ 870,200	$ 696,141	$ 696,141	$ 1,073,250	$ 1,073,250
Siding & MOW Track	$ 11,200,000	$ 11,200,000	$ 11,200,000	$ 11,200,000	$ 8,400,000	$ 8,400,000
Train Traffic Control	$ 18,780,110	$ 18,780,110	$ 18,966,569	$ 18,966,569	$ 16,112,312	$ 16,112,312
Positive Train Control	$ 4,032,820	$ 4,032,820	$ 4,072,860	$ 4,072,860	$ 3,459,940	$ 3,459,940
30% Contingency	$ 21,797,439	$ 21,797,439	$ 23,358,171	$ 23,358,171	$ 15,643,650	$ 15,643,650
Sub Total	$ 94,455,568	$ 94,455,568	$ 101,218,740	$ 101,218,740	$ 67,789,152	$ 67,789,152
Support Facilities						
Yard Track	$ 8,657,081	$ 21,730,876	$ 8,657,081	$ 21,730,876	$ 8,657,081	$ 21,730,876
Maintenance Facility	$ 19,000,000	$ 38,000,000	$ 19,000,000	$ 38,000,000	$ 19,000,000	$ 38,000,000
30% Contingency	$ 8,297,124	$ 17,919,263	$ 8,297,124	$ 17,919,263	$ 8,297,124	$ 17,919,263
Sub Total	$ 35,954,205	$ 77,650,139	$ 35,954,205	$ 77,650,139	$ 35,954,205	$ 77,650,139
Total	**$ 130,409,774**	**$ 172,105,707**	**$ 137,172,946**	**$ 178,868,879**	**$ 103,743,357**	**$ 145,439,291**

3.17 Financing of Initial Construction Costs

Given the large capital investment required to construct the UBRR within any of the three proposed rail alignments, RLBA assumed that construction of the railroad would be financed through the issuing of bonds. Specifically, RLBA assumed that the entire cost to construct the UBRR would be financed with capital generated from issuing 30-year bonds, yielding an assumed 3.13%, the published yield on a 30-year bond as reported by the U.S. Department of the Treasury as of May 1st, 2018.

Table 3-7
Annual Average Initial Capital Debt Servicing Obligation of the UBRR

Item	Rifle via Meeker Lower	Rifle via Meeker Higher
2018 Construction Cost	$ 1,347,200,000	$ 1,347,200,000
Additional Construction Cost	$ 130,409,774	$ 172,105,707
Initial Construction Cost Total	$ 1,477,609,774	$ 1,519,305,707
Construction Cost, 30 Year Bond	$ 3,724,862,858	$ 3,829,972,906
Annual Average	**$ 124,162,095**	**$ 127,665,764**

Item	Rifle via Piceance Lower	Rifle via Piceance Higher
2018 Construction Cost	$ 1,367,100,000	$ 1,367,100,000
Additional Construction Cost	$ 137,172,946	$ 178,868,879
Initial Construction Cost Total	$ 1,504,272,946	$ 1,545,968,879
Construction Cost, 30 Year Bond	$ 3,792,077,262	$ 3,897,187,309
Annual Average	**$ 126,402,575**	**$ 129,906,244**

Item	Craig Lower	Craig Higher
2018 Construction Cost	$ 1,028,000,000	$ 1,028,000,000
Additional Construction Cost	$ 103,743,357	$ 145,439,291
Initial Construction Cost Total	$ 1,131,743,357	$ 1,173,439,291
Construction Cost, 30 Year Bond	$ 2,852,978,420	$ 2,958,088,467
Annual Average	**$ 95,099,281**	**$ 98,602,949**

3.18 Feasibility of the UBRR

Using the above-described cost assumptions, RLBA determined what it has characterized as the 'annual cost obligation' associated with each of the three, potential rail alignments, assuming both the Higher and Lower volume forecasts. For purposes of this study, RLBA defines annual cost obligation as the sum of the following four values:

1. Annual Operating and Maintenance (O&M) and capital expense costs to operate the UBRR;
2. A 15% profit margin (based on O&M costs) paid to the contract short line operator assumed to operate the UBRR;
3. A 30% contingency applied to the O&M cost, capital expense cost and short line operator profit margin; and
4. Annual debt servicing obligation, assuming the entire construction cost of the railroad was financed with 30-year bonds with a 3.13% yield.

This comparison yielded the following results.

Table 3-8
Annual UBRR Cost Obligations, 2022-2042

Year	Rifle Via Meeker Area		Rifle Via Piceance Creek		Craig	
	Lower	Higher	Lower	Higher	Lower	Higher
2022	$ 151,679,388	$ 179,203,020	$ 154,169,135	$ 182,427,321	$ 118,621,360	$ 140,266,728
2023	$ 159,013,061	$ 203,394,990	$ 161,620,207	$ 207,311,438	$ 123,889,460	$ 157,986,083
2024	$ 171,966,462	$ 228,127,547	$ 174,778,590	$ 232,714,058	$ 133,309,824	$ 176,424,175
2025	$ 182,480,853	$ 229,607,112	$ 185,463,673	$ 234,240,544	$ 141,283,208	$ 177,528,440
2026	$ 184,375,678	$ 235,375,117	$ 187,395,214	$ 240,207,777	$ 142,671,970	$ 182,582,561
2027	$ 184,868,719	$ 238,254,711	$ 187,895,515	$ 243,136,187	$ 143,065,215	$ 183,731,439
2028	$ 185,368,160	$ 239,843,956	$ 188,402,288	$ 244,775,225	$ 143,463,864	$ 184,920,499
2029	$ 187,461,737	$ 245,236,965	$ 190,511,785	$ 250,303,222	$ 145,672,729	$ 189,065,328
2030	$ 187,974,258	$ 251,474,291	$ 191,031,785	$ 256,668,037	$ 146,082,439	$ 193,831,148
2031	$ 188,940,214	$ 253,140,522	$ 192,005,295	$ 258,387,108	$ 146,497,809	$ 195,074,729
2032 +	$ 191,401,532	$ 256,875,769	$ 194,515,281	$ 262,217,289	$ 148,489,587	$ 198,013,944
Average	**$ 185,701,558**	**$ 245,835,291**	**$ 188,727,429**	**$ 250,898,331**	**$ 144,100,418**	**$ 189,732,382**

RLBA's cost model suggests that in both the Higher and Lower forecast volumes, total annual cost obligations of the UBRR would be the lowest utilizing the Craig alignment. This is due to three reasons:

1. **Lower Initial Construction Cost** - The Craig alignment requires 26.04 fewer miles of new-build track as compared to the Rifle via Meeker Alignment, resulting in a cost savings of $319.2 million on the new-build construction cost alone;

2. **Less Equipment and Infrastructure Required** - Because the Craig alignment is both shorter and enjoys more benign physical characteristics than either Rifle alignment, the Craig alignment requires less equipment and infrastructure. This most noticeably manifests itself in the number of locomotives required to successfully operate the railroad, as trains operating over the Craig alignment require one less locomotive than those operating over the Rifle alignment.

3. **Lower Operating and Maintenance Costs** - Because the Craig alignment is both shorter and features more benign physical characteristics compared to either Rifle alignment, it requires a shorter amount of time for trains of any kind to transit that alignment, resulting in both fuel and train crew labor savings. Additionally, and for the same rationale, fewer MOW crews are required to adequately maintain the railroad.

3.19 'Break-Even' Transportation Rate on the UBRR

Once the annual cost obligation of each proposed alignment was determined to assess the feasibility of the UBRR as a competitive transportation option linking the Uinta Basin with the national rail network, RLBA determined the 'break even' rate on the UBRR. For purposes of this study, RLBA defines the 'break even' rate as the lowest rate which the URR could charge prospective Uinta Basin rail shippers and not operate at a loss. This value was determined by dividing the annual cost obligation by the total number of estimated annual carloads originating/terminating (including all carloads of all commodities, not limited

to crude oil) in the Uinta Basin. Because almost all rail traffic on the UBRR originates and/or terminates at either Myton or Leland Bench, carload totals remain the same within both the Higher and Lower forecasts regardless of which potential rail alignment is considered.

This comparison yielded the results shown on Table 3-9.

3.20 Lower Forecast Volume Scenarios Cash Flow upon Start Up

Theoretically, and all things being equal, for the projected volumes to move over the UBRR the transportation rates offered by the UBRR must be equal to, or, ideally, lower – a concept frequently characterized as a 'competitive rate' - than the transportation rates offered by the next best alternative transport option between the Uinta Basin and the national rail network. While transportation costs likely aren't the only consideration a shipper would weigh when selecting a transportation option – quality of service also would likely be a factor – it is probably fair to assume it would be the single most important consideration. With this in mind, it should be noted that before the completion of the ramp up period in carload volume in the Lower forecast scenarios, the breakeven rate on the UBRR regardless of alignment may be so high as to no longer be competitive against trucking, which would presumably be the next and only alternative in the event the UBRR is constructed. (SCIC is also considering a pipeline but it is the understanding of RLBA that either a railroad or pipeline would be built, but not both. Please see section 3.21). These high rates, assuming the Lower forecast volumes, may necessitate that the UBRR offer a rate lower than that which would allow the railroad to 'break even,' thus the railroad would operate cash flow negative for a period of time up upon the initial ramp up of UBRR commercial operations. This is only an issue in the Lower forecast volume scenarios; carloads are such that under the forecasted volumes in the Higher forecast, the UBRR would be able to offer competitive rates and achieve a positive cash flow immediately upon commencement of operations.

3.21 Comparing the UBRR to Alternative Transport Options beween the Uinta Basin and the National Rail Network

To quantitatively determine what, if any, transportation cost benefit the UBRR may provide to prospective Uinta Basin rail shippers, RLBA attempted to 'compare' the transportation rates of what were previously identified as the two most viable alternatives to the prospective railroad between the Myton and Leland Bench Area on the west end of the railroad and a connection with the national rail network on the east end. The values advanced below should not be considered direct comparisons of the actual transportation cost which could be achieved assuming volumes projected in either the Lower or Higher forecast. In actuality, limitations inherent to both alternatives (described below in greater detail) would preclude either from achieving the necessary capital to transport the volumes projected by RLBA.

These alternatives included:

1. **Trucking and Transloading-to-Rail Between the Uinta Basin and Price, UT** - This alternative reflects the assumption that one or more third-party trucking entities would be engaged to transport crude oil from well sites in the Uinta Basin to truck-to-rail transloading facilities in the vicinity of Price, UT, a community of approximately 9,000 located on the Union Pacific Central

Table 3-9
Rail Transportation Break-Even Rate per Carload and Barrel;
Myton/Leland Bench Area - Connection with the National Rail Network, 2022-2044

Lower

	Rifle Via Meeker Area				Rifle Via Piceance Creek				Craig			
			Break Even Rate				Break Even Rate				Break Even Rate	
Year	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel
2022	$ 151,679,388	41,629	$ 3,643.57	$ 5.69	$ 154,169,135	41,629	$ 3,703.38	$ 5.79	$ 118,621,360	41,629	$ 2,849.46	$ 4.45
2023	$ 159,013,061	60,696	$ 2,619.84	$ 4.09	$ 161,620,207	60,696	$ 2,662.80	$ 4.16	$ 123,889,460	60,696	$ 2,041.16	$ 3.19
2024	$ 171,966,462	94,018	$ 1,829.08	$ 2.86	$ 174,778,590	94,018	$ 1,858.99	$ 2.90	$ 133,309,824	94,018	$ 1,417.92	$ 2.22
2025	$ 182,480,853	121,795	$ 1,498.26	$ 2.34	$ 185,463,673	121,795	$ 1,522.75	$ 2.38	$ 141,283,208	121,795	$ 1,160.01	$ 1.81
2026	$ 184,375,678	127,750	$ 1,443.25	$ 2.26	$ 187,395,214	127,750	$ 1,466.89	$ 2.29	$ 142,671,970	127,750	$ 1,116.81	$ 1.75
2027	$ 184,868,719	128,928	$ 1,433.89	$ 2.24	$ 187,895,515	128,928	$ 1,457.37	$ 2.28	$ 143,065,215	128,928	$ 1,109.65	$ 1.73
2028	$ 185,368,160	130,118	$ 1,424.62	$ 2.23	$ 188,402,288	130,118	$ 1,447.94	$ 2.26	$ 143,463,864	130,118	$ 1,102.57	$ 1.72
2029	$ 187,461,737	131,319	$ 1,427.53	$ 2.23	$ 190,511,785	131,319	$ 1,450.75	$ 2.27	$ 145,672,729	131,319	$ 1,109.30	$ 1.73
2030	$ 187,974,258	132,533	$ 1,418.32	$ 2.22	$ 191,031,785	132,533	$ 1,441.39	$ 2.25	$ 146,082,439	132,533	$ 1,102.23	$ 1.72
2031	$ 188,940,214	133,759	$ 1,412.54	$ 2.21	$ 192,005,295	133,759	$ 1,435.46	$ 2.24	$ 146,497,809	133,759	$ 1,095.24	$ 1.71
2032 +	$ 191,401,532	134,997	$ 1,417.82	$ 2.22	$ 194,515,281	134,997	$ 1,440.89	$ 2.25	$ 148,489,587	134,997	$ 1,099.95	$ 1.72
Average	**$ 185,701,558**	**124,351**	**$ 1,493.36**	**$ 2.33**	**$ 188,727,429**	**124,351**	**$ 1,517.69**	**$ 2.37**	**$ 144,100,418**	**124,351**	**$ 1,158.82**	**$ 1.81**

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Higher

	Rifle Via Meeker Area				Rifle Via Piceance Creek				Craig			
			Break Even Rate				Break Even Rate				Break Even Rate	
Year	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel	Expense	Carloads	Carload	Barrel
2022	$ 179,203,020	95,753	$ 1,871.52	$ 2.92	$ 182,427,321	95,753	$ 1,905.19	$ 2.98	$ 140,266,728	95,753	$ 1,464.89	$ 2.29
2023	$ 203,394,990	161,408	$ 1,260.13	$ 1.97	$ 207,311,438	161,408	$ 1,284.39	$ 2.01	$ 157,986,083	161,408	$ 978.80	$ 1.53
2024	$ 228,127,547	224,984	$ 1,013.97	$ 1.58	$ 232,714,058	224,984	$ 1,034.36	$ 1.62	$ 176,424,175	224,984	$ 784.16	$ 1.23
2025	$ 229,607,112	229,436	$ 1,000.75	$ 1.56	$ 234,240,544	229,436	$ 1,020.94	$ 1.60	$ 177,528,440	229,436	$ 773.76	$ 1.21
2026	$ 235,375,117	248,360	$ 947.72	$ 1.48	$ 240,207,777	248,360	$ 967.18	$ 1.51	$ 182,582,561	248,360	$ 735.15	$ 1.15
2027	$ 238,254,711	252,991	$ 941.75	$ 1.47	$ 243,136,187	252,991	$ 961.05	$ 1.50	$ 183,731,439	252,991	$ 726.24	$ 1.13
2028	$ 239,843,956	257,778	$ 930.43	$ 1.45	$ 244,775,225	257,778	$ 949.56	$ 1.48	$ 184,920,499	257,778	$ 717.36	$ 1.12
2029	$ 245,236,965	269,788	$ 909.00	$ 1.42	$ 250,303,222	269,788	$ 927.78	$ 1.45	$ 189,065,328	269,788	$ 700.79	$ 1.09
2030	$ 251,474,291	281,832	$ 892.28	$ 1.39	$ 256,668,037	281,832	$ 910.71	$ 1.42	$ 193,831,148	281,832	$ 687.75	$ 1.07
2031	$ 253,140,522	286,845	$ 882.50	$ 1.38	$ 258,387,108	286,845	$ 900.79	$ 1.41	$ 195,074,729	286,845	$ 680.07	$ 1.06
2032 +	$ 256,875,769	291,959	$ 879.83	$ 1.37	$ 262,217,289	291,959	$ 898.13	$ 1.40	$ 198,013,944	291,959	$ 678.23	$ 1.06
Average	**$ 245,835,291**	**267,656**	**$ 918.48**	**$ 1.44**	**$ 250,898,331**	**267,656**	**$ 937.39**	**$ 1.47**	**$ 189,732,382**	**267,656**	**$ 708.87**	**$ 1.11**

Corridor, approximately 225 miles west of Rifle. Price was selected as the terminus due to the fact that much of the Uinta Basin crude oil previously shipped out of the state of Utah by rail has been transloaded and shipped from facilities in the Helper, Price and Wellington area. RLBA assumed that transloading occurs at a hypothetical, unnamed transloading facility near Price. Values related to trucking and transloading costs under this alternative were developed by RLBA team member, Helios Group, Inc., based on data collected during stakeholder interviews and proprietary information maintained by Helios Group.

As referenced above, it is important to note that RLBA does not believe that it is practical or reasonable to assume that the truck-to-rail transloading alternative realistically could move the volumes of traffic projected in the later years of either the Lower or Higher forecast. Research suggests that the maximum volume of crude oil moved by truck from the Uinta Basin to rail transloading facilities peaked at 32,000. This value represents only approximately 20% and 10% of the daily production projected in the Lower and Higher forecasts, respectively, beyond 2034, nor does it include any volume associated with the other commodities coming into and out of the Uinta Basin. Increasing transloading volume beyond 32,000 bpd is unlikely due to: 1) the challenging, mountainous characteristics of the road connecting the Uinta Basin and the Price area; 2) hazardous driving conditions on said roads during winter months and 3) the inability to expand or improve existing roads, due to, among other factors, said roads passing through the Ashley National Forest. As such, the values advanced in this study are provided only to attempt to quantify the potential transportation cost-benefit the UBRR may provide to prospective Uinta Basin rail shippers

2. **Piping and Transloading-to-Rail Between the Uinta Basin and Price, UT** - This alternative reflects the assumption of the construction and operation of a dedicated, 70,000 bpd crude oil pipeline between Myton, UT and the aforementioned Price River Terminal, at which crude oil would transload from pipe to rail. Values associated with this alternative were determined by subtracting RLBA Team-developed transloading and rail shipping costs from a baseline, all-in, per barrel cost, developed previously and independently of this study by HDR, Inc. in 2017, as part of a study entitled "Uinta Basin Oil Pipeline Study."

   As with the truck-to-rail transloading alterative, it is important to note that, as currently defined, the pipe-to-rail alterative also could not realistically move the volumes of traffic projected in the later years of either the Lower or Higher forecast. The 70,000 bpd crude oil pipeline defined in the HDR study could only handle approximately 45% and 20% of the daily production projected in the Lower and Higher forecasts, respectively, beyond 2034, nor does it include any volume associated with the other commodities coming into and out of the Uinta Basin. Since a pipeline cannot be 'scaled up' if oil volumes increase beyond its capacity, a proposed pipeline would need to be larger than the version previously investigated. This is particularly true in light of the fact that previous studies determined that there is not enough available right-of-way for a second pipeline to be constructed along the same corridor. As such, the values advanced in this study are provided only to attempt to quantify the potential transportation cost-benefit the UBRR may provide to prospective Uinta Basin rail shippers.

To provide a fair comparison between the UBRR and the above-described transportation alternatives, RLBA included a pro-rated value to capture the cost of leasing a railcar in which to ship commodities between the Uinta Basin and a connection with the national rail network (rail car leasing costs are addressed in more depth in section 4.6).

This comparison yielded the following results.

Table 3-10
Alternative Transportation Rate Comparison per Barrel;
Myton/Leland Bench Area - Connection with the National Rail Network

Item	Rail						Truck	Pipeline
	Rifle via Meeker		Rifle Via Piceance		Craig		Cost	Cost
	Lower	Higher	Lower	Higher	Lower	Higher		
Rail Car Lease	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ -	$ -
Transport to National Network	$ 2.33	$ 1.44	$ 2.37	$ 1.47	$ 1.81	$ 1.11	$ 3.00	$ 1.40
Transload at National Network	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.50	$ 1.50
Total	**$ 2.50**	**$ 1.60**	**$ 2.54**	**$ 1.63**	**$ 1.98**	**$ 1.27**	**$ 4.50**	**$ 2.90**

RLBA's results indicated that in both the Higher and Lower forecast, the UBRR would provide the lowest transportation cost between the Myton/Leland Bench, UT, area and a connection with the national rail network. These results were due to the fact that: 1) the high volumes of commodities estimated to ship via rail, including those other than crude oil, greatly amplify the superior economics of scale intrinsic to rail; and 2) the additional cost of transloading or 'double handling' crude oil into railcars at the connection to the national rail network negatively impacts the competitiveness of non-rail transportation options.

While transportation cost is the most important factor in the determination of a particular transportation option's competitiveness, it is not the only consideration. The flexibility that a railroad provides in comparison to a pipeline – the ability to transport multiple types of commodities, in both directions – offers a significant non-monetary service advantage over a pipeline. The next best alternative as regards cost, which can only transport one type of commodity, in a single direction at a time. This flexibility was cited by several prospective Uinta Basin rail shippers whom expressed a preference towards a rail connection serving the Uinta Basin rather than a pipeline. Additionally, unlike a pipeline which essentially cannot be significantly altered or expanded upon, a rail option would be relatively 'scalable,' in that additional infrastructure could be added as needed, at an economical cost.

3.22 Comparing the UBRR to Alternative Transport Options between the Uinta Basin and Salt Lake City

While the primary objective of this study was to determine transportation rates/costs to distant markets, the Salt Lake City markets are currently, and figure to remain under any expansion scenario, a major, market for Uinta Basin crude oil. As such, RLBA compared the cost of the various transportation options previously identified against the real world cost paid today to transport Uinta Basin crude oil to Salt Lake City via contract trucking. RLBA considered six transportation options, including:

1. **All Rail Between the Uinta Basin and Salt Lake City, UT** - Considering the three prospective rail alignments address earlier in this report;

2. **Trucking and Transloading-to-Rail between the Uinta Basin and Salt Lake City, UT via Price, UT** - As addressed earlier in this report;

3. **Piping and Transloading-to-Rail between the Uinta Basin and Salt Lake City, UT via Price, UT** - As addressed earlier in this report; and

4. **All Truck between the Uinta Basin and Salt Lake City, UT** considering the current, real world cost to transport crude oil from a central location in the Uinta Basin (defined as Myton, UT to facilitate a fair comparison to transport cost of the other options) directly to Salt Lake City, UT refineries. These costs were developed in conjunction with Mr. Eckels.

This comparison yielded the following results.

Table 3-11
Alternative Transportation Rate Comparison per Barrel;
Myton/Leland Bench Area - Salt Lake City Markets

	Rail						Truck		Pipeline
	Rifle via Meeker		Rifle Via Piceance		Craig				
Item	Lower	Higher	Lower	Higher	Lower	Higher	Price	Salt Lake	Price
Rail Car Lease	$ 0.64	$ 0.64	$ 0.64	$ 0.64	$ 0.71	$ 0.71	$ 0.54	$ -	$ -
Transport to National Network	$ 2.33	$ 1.44	$ 2.37	$ 1.47	$ 1.81	$ 1.11	$ 3.00	$ -	$ -
Transload at National Network	$ -	$ -	$ -	$ -	$ -	$ -	$ 1.50	$ -	$ -
Union Pacific to Salt Lake City	$ 1.68	$ 1.68	$ 1.68	$ 1.68	$ 2.42	$ 2.42	$ 0.77	$ -	$ -
BNSF Railway to Salt Lake City	$ 1.71	$ 1.71	$ 1.71	$ 1.71	$ -	$ -	$ 0.77	$ -	$ -
Truck to Salt Lake City (HDR)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5.75	$ -
Truck-Pipe-Rail-Pipe (HDR)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6.11
Transload at Salt Lake City	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ 1.50	$ -	$ -
Total via UP	**$ 6.16**	**$ 5.26**	**$ 6.20**	**$ 5.29**	**$ 6.44**	**$ 5.74**	**$ 7.31**	**$ -**	**$ -**
Total via BNSF	**$ 6.19**	**$ 5.29**	**$ 6.23**	**$ 5.32**	**$ -**	**$ -**	**$ 7.32**	**$ -**	**$ -**
Best PossibleTotal	**$ 6.16**	**$ 5.26**	**$ 6.20**	**$ 5.29**	**$ 6.44**	**$ 5.74**	**$ 7.31**	**$ 5.75**	**$ 6.11**

UP and BNSF rates to Salt Lake City represent an average of all estimated rates to all Salt Lake City area refineries

RLBA's results indicated that at the High forecast volume estimates, an all-rail routing assuming interchange with Union Pacific at Rifle, CO, provided the most competitive transportation cost. However, at the Low forecast volume estimates, the current practice of trucking directly to Salt Lake City offered the most competitive cost. Not captured in RLBA's results is the cost to construct the required facilities to accept and handle railcars at Salt Lake City area refineries, nor the cost to the taxpayers of Utah to maintain U.S. Route 40 (and associated routes between the Uinta Basin and Salt Lake City), which are not reflected in the trucking rates.

4.0 Approach Part 3 - Determination of Costs to Ship across the National Rail Network to/from Distant Markets

4.1 Summary of RLBA Approach

RLBA employed a two-step process to determine the cost to ship across the national rail network to/from distant markets, including:

1. Determining Estimated Freight Rates across the National Rail Network;
2. Determining Rail Equipment Lease Rates and
3. Determining the 'All-In' Transportation Cost across the National Rail Network.

4.2 Determining Estimated Freight Rates across the National Rail Network

The national network (UP and BNSF) rail rates are particularly important to prospective Uinta Basin rail shippers and the viability of the UBRR because said rates are likely to be the single largest transportation cost component involved in moving Uinta Basin commodities to/from markets/sources. These rates, and those on the other seven commodities, also are important because they influence the rates which the UBRR would be able to charge on its portion of the overall rail haul and, thus, influence the economic feasibility of the UBRR.

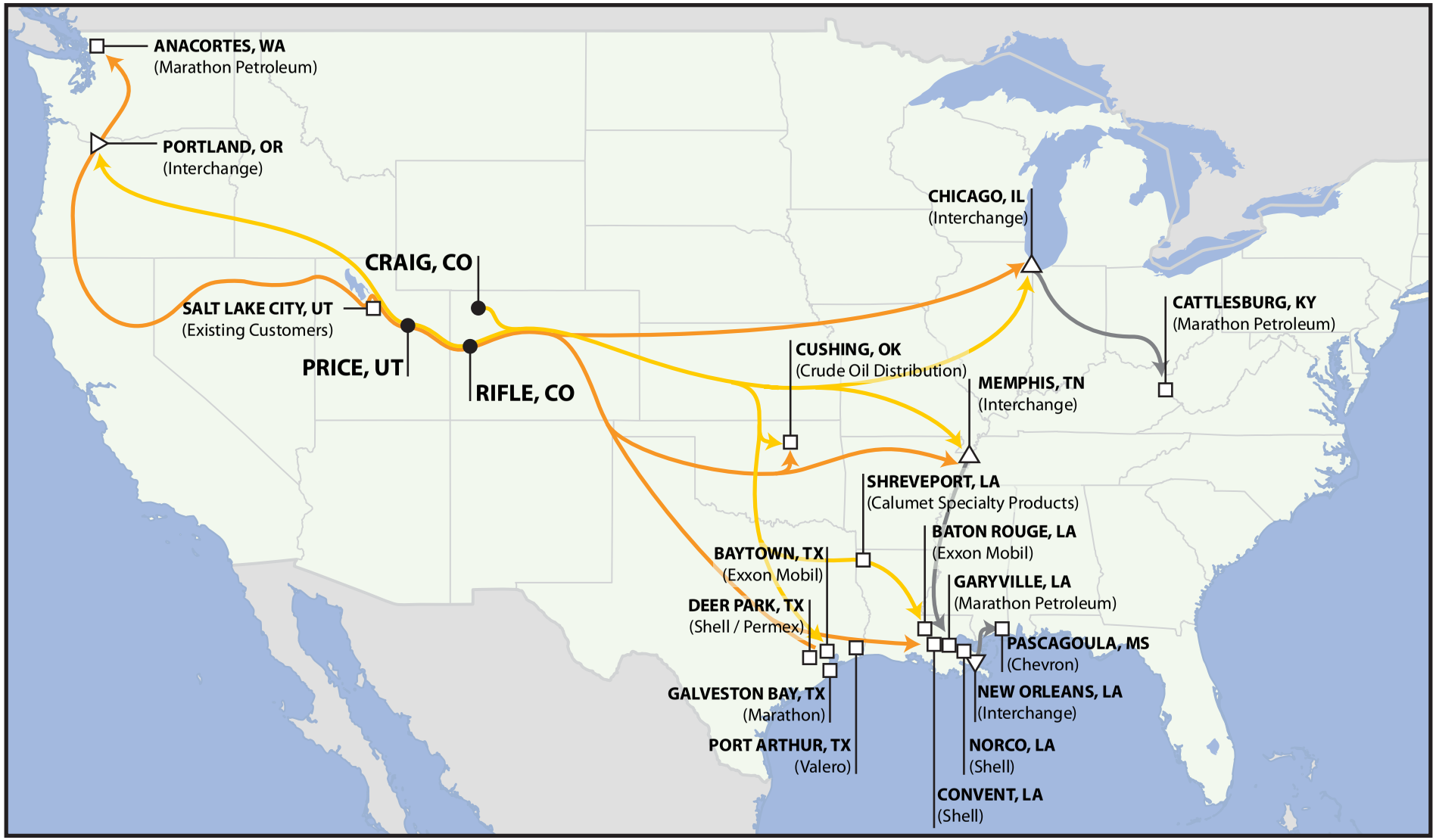
Estimated rates which prospective Uinta Basin rail shippers might pay to transport Uinta Basin crude oil via UP routings and BNSF routings across the national rail system to eleven target refineries were determined by RLBA from both proposed eastern termini – Rifle, CO and Craig, CO – as well as the proposed terminus of the two previously identified alternative transport options – Price, UT. At the request of SCIC, RLBA also provided estimated rates to the closest railhead to Cushing, OK. Finally, RLBA estimated prospective rates on seven other commodities involving eleven potential destinations (of shale oil, refined oil products, etc.) and four potential origins (of frac sand and pipe), also from Rifle, CO, Craig, CO and Price, UT.

The rates which either UP or BNSF may charge prospective Uinta Basin shippers are determined by five factors which are briefly described below.

1. **Demand for Products** - Demand for the products and raw materials being sold in the economy determine the demand for rail transportation, as is the case with all modes of transportation. Hence, rail transportation is referred to as a 'derived-demand industry' in economics circles. At the individual rail customer level, this translates into the amount (barrels, tons or carloads) of product or raw material which a freight generator thinks it can sell or purchase and then ship. The volume of a customer's demand provides the customer with some leverage in its rate negotiation with a railroad.

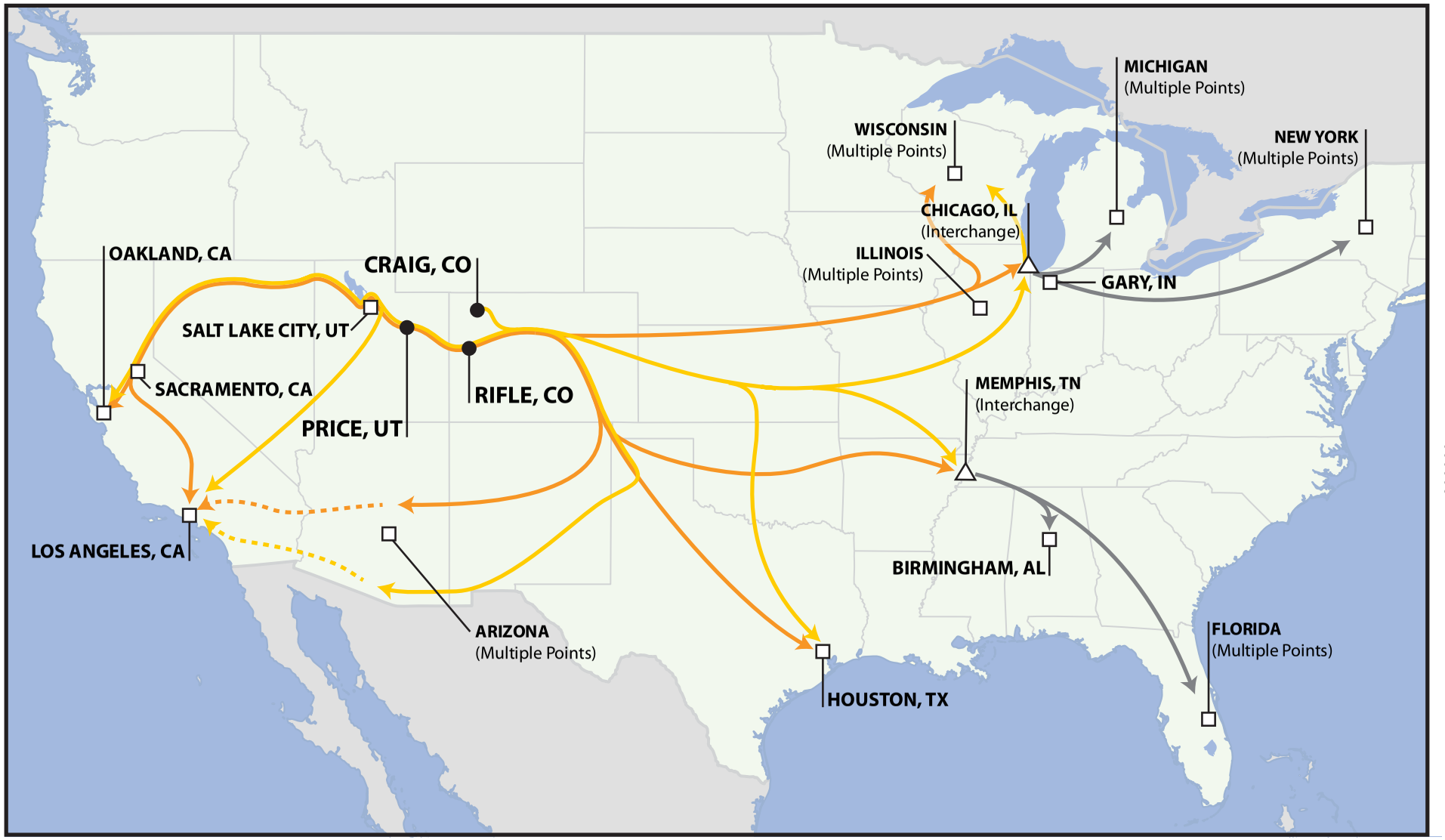
2. **Profit Goals of the Railroad** - Profit goals of a railroad determine the degree to which it exercises its market power to mark-up its cost per carload to the rate which it feels will maximize its profitability. RLBA evaluated the profit goals of BNSF and UP, the railroads with which the Uinta

Map 4-1
Proposed National Destinations and Routings for Uinta Basin Crude Oil



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Map 4-2
Proposed National Origins/Destinations and Routings for Other Uinta Basin Commodities



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Basin traffic would be interchanged, by reviewing estimated revenue/variable cost (R/VC) ratios of the railroads. R/VC ratios are a common metric by which railroads measure the profitability of individual shipments.

3. **Cost Per Carload** - A railroad's cost to transport a carload is the baseline against which the profitability of a given carload is measured by a railroad. The average cost per carload is calculated in terms of long-term variable costs, which include the costs of items such as: owning and maintaining mainline track network and switching yards, owning and maintaining locomotives and rail cars and recruiting and paying its workforce. The extent to which such costs are allocated against a given carload is determined by the number of times the railroad must switch (handle) it during the course of its trip, its length of haul and its weight.

4. **Alternative Transportation Options** - A shipper's access to competing transport options is the most important factor in attempting to manage the level of rates charged by a railroad. In addition to securing access to competing carriers at a specific location, such as Rifle, CO or Price, UT, access to transport options includes a customer's ability to shift production and raw material sourcing among multiple facilities and vendors to leverage shipping volumes and carrier competition at those locations where feasible. RLBA considered the specific location level of access in its rate analysis by producing prospective rates which reflected assumed routings via two competing rail carriers, BNSF and UP. RLBA also evaluated modal competitive options (truck and pipeline) between the Uinta Basin and Price, UT.

5. **Level of Service** - The level of service required by a customer can influence the rate charged by a railroad because it might impact a railroad's cost of providing service. The most prominent level of service element is the frequency (daily vs. Monday – Wednesday – Friday) with which a customer's facility is switched by a railroad. Daily service might require a railroad to incur overtime on a crew while the three-day-a-week service could be accomplished within a crew's normal eight-hour day. Where a customer relies upon a railroad to provide rail cars into which it loads its product, the ability of the railroad to reliably provide a sufficient supply of rail cars is a metric on which customers measure a railroad's level of service. For purposes of determining prospective rates, RLBA assumed that daily service would be provided at the Uinta Basin locations and that a sufficient supply of rail cars would be provided by railroads to move the commodities which would require railroad-supplied equipment.

The application of this methodology yielded the following results.

Table 4-1
Rail Transportation Rate per Carload and per Barrel, Oil; Connection with the National Rail Network - National Markets

			Per Carload				
	Oil Type		Union Pacific			BNSF Railway	
	Destination	Customer	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
LA	Shreveport	Crude - Calumet	$ 4,181	$ 4,125	$ 4,709	$ 3,675	$ 4,194
MS	Pascagoula	Crude - Chevron	$ 5,277	$ 5,221	$ 5,805	$ 4,642	$ 5,159
LA	Baton Rouge	Crude - Exxon Mobil	$ 4,610	$ 4,554	$ 5,138	$ 4,393	$ 4,912
TX	Baytown	Crude - Exxon Mobil	$ 3,935	$ 3,879	$ 4,463	$ 3,408	$ 3,926
KY	Catlettsburg	Crude - Marathon	$ 5,054	$ 4,999	$ 5,830	$ 4,690	$ 5,332
LA	Garyville	Crude - Marathon	$ 5,472	$ 5,416	$ 6,000	$ 5,050	$ 5,566
TX	Galveston Bay	Crude - Marathon	$ 3,974	$ 3,919	$ 4,503	$ 3,428	$ 3,946
WA	Anacortes	Crude - Marathon	$ 4,637	$ 4,164	$ 3,580	$ 4,233	$ 3,718
TX	Port Arthur	Crude - Motiva	$ 4,102	$ 4,046	$ 4,630	$ 3,541	$ 4,058
LA	Norco	Crude - Shell	$ 5,423	$ 5,367	$ 5,951	$ 5,001	$ 5,518
LA	Convent	Crude - Shell	$ 5,516	$ 5,460	$ 6,045	$ 5,094	$ 5,609
TX	Deer Park	Crude - Shell / Pemex	$ 3,851	$ 3,754	$ 4,338	$ 3,619	$ 4,129
TX	Port Arthur	Crude - Valero	$ 4,102	$ 4,046	$ 4,630	$ 3,541	$ 4,058
OK	Cushing	Crude - Transload	$ 2,854	$ 2,798	$ 3,382	$ 2,466	$ 2,985
UT	North Salt Lake	Crude - Big West Oil	$ 1,555	$ 1,082	$ 498	$ 1,102	$ 501
UT	Salt Lake City	Crude - Chevron	$ 1,541	$ 1,068	$ 484	$ 1,086	$ 485
UT	Salt Lake City	Crude - Tesoro	$ 1,541	$ 1,068	$ 484	$ 1,086	$ 485
UT	Woods Cross	Crude - HollyFrontier	$ 1,564	$ 1,091	$ 507	$ 1,113	$ 512
UT	Salt Lake City	Shale - Enefit	$ 3,486	$ 2,658	$ 1,680	$ 2,398	$ 1,518
CA	Los Angeles	Shale - Enefit	$ 6,264	$ 5,494	$ 4,509	$ 6,264	$ 5,392
TX	Houston	Shale - Enefit	$ 5,932	$ 5,999	$ 6,631	$ 5,005	$ 5,600
			Per Barrel				
LA	Shreveport	Crude - Calumet	$ 6.53	$ 6.45	$ 7.36	$ 5.74	$ 6.55
MS	Pascagoula	Crude - Chevron	$ 8.25	$ 8.16	$ 9.07	$ 7.25	$ 8.06
LA	Baton Rouge	Crude - Exxon Mobil	$ 7.20	$ 7.12	$ 8.03	$ 6.86	$ 7.67
TX	Baytown	Crude - Exxon Mobil	$ 6.15	$ 6.06	$ 6.97	$ 5.33	$ 6.13
KY	Catlettsburg	Crude - Marathon	$ 7.90	$ 7.81	$ 9.11	$ 7.33	$ 8.33
LA	Garyville	Crude - Marathon	$ 8.55	$ 8.46	$ 9.38	$ 7.89	$ 8.70
TX	Galveston Bay	Crude - Marathon	$ 6.21	$ 6.12	$ 7.04	$ 5.36	$ 6.17
WA	Anacortes	Crude - Marathon	$ 7.25	$ 6.51	$ 5.59	$ 6.61	$ 5.81
TX	Port Arthur	Crude - Motiva	$ 6.41	$ 6.32	$ 7.23	$ 5.53	$ 6.34
LA	Norco	Crude - Shell	$ 8.47	$ 8.39	$ 9.30	$ 7.81	$ 8.62
LA	Convent	Crude - Shell	$ 8.62	$ 8.53	$ 9.45	$ 7.96	$ 8.76
TX	Deer Park	Crude - Shell / Pemex	$ 6.02	$ 5.87	$ 6.78	$ 5.66	$ 6.45
TX	Port Arthur	Crude - Valero	$ 6.41	$ 6.32	$ 7.23	$ 5.53	$ 6.34
OK	Cushing	Crude - Transload	$ 4.46	$ 4.37	$ 5.28	$ 3.85	$ 4.66
UT	North Salt Lake	Crude - Big West Oil	$ 2.43	$ 1.69	$ 0.78	$ 1.72	$ 0.78
UT	Salt Lake City	Crude - Chevron	$ 2.41	$ 1.67	$ 0.76	$ 1.70	$ 0.76
UT	Salt Lake City	Crude - Tesoro	$ 2.41	$ 1.67	$ 0.76	$ 1.70	$ 0.76
UT	Woods Cross	Crude - HollyFrontier	$ 2.44	$ 1.70	$ 0.79	$ 1.74	$ 0.80
UT	Salt Lake City	Shale - Enefit	$ 5.45	$ 4.15	$ 2.63	$ 3.75	$ 2.37
CA	Los Angeles	Shale - Enefit	$ 9.79	$ 8.58	$ 7.05	$ 9.79	$ 8.42
TX	Houston	Shale - Enefit	$ 9.27	$ 9.37	$ 10.36	$ 7.82	$ 8.75

Red emphasis indicates highest rate, green emphasis indicates lowest rate

Table 4-2
Rail Transportation Rate per Carload, Other Commodities; Connection with the National Rail Network - National Markets

			Union Pacific			BNSF Railway	
	Destination	Commodity	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
CA	Oakland	Refined Oil Products	$ 3,764	$ 3,351	$ 2,821	$ 3,959	$ 3,394
TX	Houston	Refined Oil Products	$ 4,402	$ 4,352	$ 4,863	$ 4,076	$ 4,641
CA	Los Angeles	Sodium Bicarbonate	$ 4,534	$ 3,982	$ 3,273	$ 4,794	$ 4,279
TX	Houston	Sodium Bicarbonate	$ 5,894	$ 5,830	$ 6,511	$ 3,726	$ 4,241
CA	Oakland	Fly Ash - DGT	$ 3,894	$ 3,466	$ 2,919	$ 3,173	$ 2,721
CA	Sacramento	Fly Ash - DGT	$ 3,584	$ 3,156	$ 2,609	$ 2,981	$ 2,514
CA	Oakland	Gilsonite	$ 5,122	$ 4,599	$ 3,900	$ 4,102	$ 3,568
TX	Houston	Gilsonite	$ 5,927	$ 5,866	$ 6,512	$ 4,212	$ 4,746
WI	La Crosse	Frac Sand	$ 4,773	$ 4,700	$ 5,764	$ 4,226	$ 5,047
IL	Chicago	Frac Sand	$ 4,490	$ 4,418	$ 5,482	$ 4,012	$ 4,833
AL	Birmingham	Steel Pipe	$ 10,686	$ 10,589	$ 11,605	$ 9,673	$ 10,750
IN	Gary	Steel Pipe	$ 7,767	$ 7,670	$ 8,685	$ 8,416	$ 9,492

Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

Railroad rates are greatly influenced by the length of haul between origins and destinations. Twelve of the thirteen target refineries are located to the southeast and east (in Kentucky, Louisiana, Mississippi and Texas) of the three candidate terminal/junction locations (Craig, CO; Price, UT and Rifle, CO). Another target refinery is located in Anacortes, WA, to the northwest (opposite direction) of most candidate terminals. The closer a candidate terminal is to those southeastern and south-central states, the lower the rates it would logically enjoy, generally because the lengths of haul are shorter. This is the case with the prospective Uinta Basin crude oil rates, resulting in the following findings:

1. **Rifle, CO** - Produces the lowest rates of the three candidate terminals on the Uinta Basin crude oil to the twelve target refineries. Prospective rates via UP and its connections (UP routings) are $50 – 100 lower than rates from Craig, CO. Prospective rates via BNSF and its connections (BNSF routings) suggest that the spread between Rifle and Craig rates has the potential to be larger – in the range of $200 – 600. As would be expected, prospective rates on Uinta Basin crude oil from Rifle, CO are lower than from Price, UT because Price is farther from the twelve target refineries: $530 – 590 via UP routings and generally $515 – 520 lower via BNSF routings.

2. **Price, UT** - Produces the lowest rates to the target refinery in Anacortes, WA. The prospective rates are at least $500 lower than the rates from next closest candidate terminal, Rifle, CO, via BNSF and UP routings. This is not surprising because Price, UT is significantly closer to Anacortes, WA.

3. **Prospective rates on the seven, non-crude oil Uinta Basin commodities** generally display the same pattern as illustrated above: commodities moving to or from destinations and origins located in the South, Southeast and East find the lowest rates at Rifle, CO while those located in the West and Northwest find the lowest rates at Price, UT.

4. **Comparison of BNSF routings with UP routings at Rifle, CO and Price, UT** - Indicates that most BNSF routings produce shorter lengths of haul than UP routings. For instance, BNSF's operating mileages between Rifle, CO and four of the target refineries in Texas are between 168 and 332 miles shorter than UP's. This is largely because BNSF's mainline network provides a shorter, more direct route between the candidate terminals and the Gulf Coast region of Texas, Louisiana and Mississippi. The shorter mainline network routing provides BNSF with a somewhat lower operating cost structure to many of the target refineries, which has resulted in lower rates in RLBA's analysis.

4.3 Explanation of Methodology Used in Determining Estimated Freight Rates across the National Rail Network

The rates presented by RLBA in this analysis are characterized as "prospective rates" because they are estimates of rates which a rail shipper might achieve through negotiations with BNSF and UP or through access to BNSF and UP rate tariffs. They have been developed by RLBA's lane-by-lane analysis of the following data available through RSII Logistics' USRail rail rate and traffic analysis software, a third-party rail rate and costing software employed by RLBA:

1. Long-term variable costs per carload which the railroads would incur in transporting unit trains or individual carloads across their lines;
2. Benchmark Revenue/Variable Cost (R/VC) ratios calculated from government databases on a commodity-specific and car-type specific basis;
3. Operating miles and
4. Average revenue per car for individual commodities hauled on BNSF and UP.

As previously mentioned, R/VC ratio is another key element which RLBA considered in determining prospective Class I rail rates in its analysis. RLBA reviewed R/VC benchmarks regarding each lane which it generated with RSI's US Rail Impact tool. US Rail Impact's R/VC benchmarks are developed from RSI's analysis of revenues and variable costs by commodity and equipment (rail car) type which appear in a database maintained by the U.S. Surface Transportation Board (STB).

4.4 Union Pacific Rates

RLBA considered R/VC's on crude oil rates found in a current UP tariff which apply on shipments from Utah in manifest train service. Manifest train service is general freight train service in which one carload to 30 or 40 carloads of crude might be shipped as part of a larger train hauling various commodities. RLBA found rates in the tariff which apply to destinations relevant to this study, such as Louisiana, Mississippi and Texas and entered them into the US Rail Impact tool to calculate their R/VC's (profit margins). While not directly applicable to unit train service in which Uinta Basin crude would be transported, these R/VC's provided another set of benchmarks against which RLBA tested the appropriateness of its prospective crude oil rates.

4.5 BNSF Railway Rates

This analysis reflects the assumption that rail shippers and public officials would be able to convince BNSF to establish Price, UT and Rifle, CO as stations on its network. Both locations already are stations on UP. BNSF's willingness to publish competing rates and services at existing UP stations will be either tempered or encouraged by a variety of factors, including its existing commercial relationships with producers, marketers, other rail shippers and transload operators at existing BNSF stations which are proximate to the candidate terminals. Wellington, UT (BNSF) and Price, UT (UP) are only six miles apart. Parachute, CO (BNSF) and Rifle, CO (UP) are fifteen miles apart. Such concerns might be overcome, of course, by the prospect of significant amounts of new traffic.

4.6 Determining Rail Equipment Lease Rates

Freight rates charged by the railroads are only one of the two rail-related charges which a rail customer commonly must pay if the serving railroad does not provide rail cars and the shipper must acquire them, generally by leasing.. Railroads generally do not provide tank cars, such as those which would be required to transport Uinta Basin Crude, shale oil and refined oil products, due to the wide variety of specifications (capacity, lining, pressure, loading/unloading fixtures, etc.) required to safely carry a wide variety of commodities and the volatility in demand for such cars. Covered hopper cars, such as those required to transport frac sand, sodium bicarbonate and fly ash, are predominantly provided by the shippers as well. Class I railroads have frac sand-capable cars in their fleets but most of the frac sand shipments observed in RLBA's research moved in shipper-leased (private) rail cars.

This gives rise to equipment (rail car) lease costs which, generally, must be borne directly by the shipper who tenders the freight at origin, such as a Uinta Basin crude oil marketer. Lease costs are commonly thought of in terms of an average equipment cost per load and effectively become an add-on to the freight rate paid by the rail shipper (lessee). Rail equipment lease costs also are borne – indirectly - by a rail receiver such as a prospective Uinta Basin rail customer who supplies frac sand arriving by rail. The price which said prospective customer pays for a carload of frac sand typically will include the supplier's average cost of leasing the fleet of covered hopper cars in which the frac sand is transported.

With that in mind, RLBA determined the following estimates of the average private equipment costs per carload (lease cost per carload) by each of the commodity groups and traffic lanes in the analysis.

Table 4-3
Equipment Lease Rate Per Carload and per Barrel, Crude Oil; Connection with the National Network - National Markets

Per Carload							
Oil Type			Union Pacific			BNSF Railway	
Destination		Customer	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
LA	Shreveport	Crude - Calumet	$ 615	$ 611	$ 630	$ 592	$ 607
MS	Pascagoula	Crude - Chevron	$ 615	$ 611	$ 630	$ 592	$ 607
LA	Baton Rouge	Crude - Exxon Mobil	$ 615	$ 611	$ 630	$ 592	$ 607
TX	Baytown	Crude - Exxon Mobil	$ 615	$ 611	$ 630	$ 592	$ 607
KY	Catlettsburg	Crude - Marathon	$ 615	$ 611	$ 630	$ 592	$ 607
LA	Garyville	Crude - Marathon	$ 615	$ 611	$ 630	$ 592	$ 607
TX	Galveston Bay	Crude - Marathon	$ 615	$ 611	$ 630	$ 592	$ 607
WA	Anacortes	Crude - Marathon	$ 615	$ 611	$ 630	$ 592	$ 607
TX	Port Arthur	Crude - Motiva	$ 615	$ 611	$ 630	$ 592	$ 607
LA	Norco	Crude - Shell	$ 615	$ 611	$ 630	$ 592	$ 607
LA	Convent	Crude - Shell	$ 615	$ 611	$ 630	$ 592	$ 607
TX	Deer Park	Crude - Shell / Pemex	$ 615	$ 611	$ 630	$ 592	$ 607
TX	Port Arthur	Crude - Valero	$ 615	$ 611	$ 630	$ 592	$ 607
OK	Cushing	Crude - Transload	$ 615	$ 611	$ 630	$ 592	$ 607
UT	North Salt Lake	Crude - Big West Oil	$ 346	$ 302	$ 238	$ 302	$ 238
UT	Salt Lake City	Crude - Shevron	$ 346	$ 302	$ 238	$ 302	$ 238
UT	Salt Lake City	Crude - Tesoro	$ 346	$ 302	$ 238	$ 302	$ 238
UT	Woods Cross	Crude - HollyFrontier	$ 346	$ 302	$ 238	$ 302	$ 238
UT	Salt Lake City	Shale - Enefit	$ 652	$ 611	$ 555	$ 611	$ 555
CA	Los Angeles	Shale - Enefit	$ 909	$ 860	$ 760	$ 972	$ 916
TX	Houston	Shale - Enefit	$ 1,013	$ 968	$ 987	$ 898	$ 916
Per Barrel							
LA	Shreveport	Crude - Calumet	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
MS	Pascagoula	Crude - Chevron	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
LA	Baton Rouge	Crude - Exxon Mobil	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
TX	Baytown	Crude - Exxon Mobil	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
KY	Catlettsburg	Crude - Marathon	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
LA	Garyville	Crude - Marathon	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
TX	Galveston Bay	Crude - Marathon	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
WA	Anacortes	Crude - Marathon	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
TX	Port Arthur	Crude - Motiva	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
LA	Norco	Crude - Shell	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
LA	Convent	Crude - Shell	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
TX	Deer Park	Crude - Shell / Pemex	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
TX	Port Arthur	Crude - Valero	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
OK	Cushing	Crude - Transload	$ 0.96	$ 0.95	$ 0.98	$ 0.93	$ 0.95
UT	North Salt Lake	Crude - Big West Oil	$ 0.54	$ 0.47	$ 0.37	$ 0.47	$ 0.37
UT	Salt Lake City	Crude - Shevron	$ 0.54	$ 0.47	$ 0.37	$ 0.47	$ 0.37
UT	Salt Lake City	Crude - Tesoro	$ 0.54	$ 0.47	$ 0.37	$ 0.47	$ 0.37
UT	Woods Cross	Crude - HollyFrontier	$ 0.54	$ 0.47	$ 0.37	$ 0.47	$ 0.37
UT	Salt Lake City	Shale - Enefit	$ 1.02	$ 0.95	$ 0.87	$ 0.95	$ 0.87
CA	Los Angeles	Shale - Enefit	$ 1.42	$ 1.34	$ 1.19	$ 1.52	$ 1.43
TX	Houston	Shale - Enefit	$ 1.58	$ 1.51	$ 1.54	$ 1.40	$ 1.43

Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

Table 4-4
Equipment Lease Rate per Carload, Other Commodities;
Connection with the National Rail Network - National Markets

			Union Pacific			BNSF Railway	
	Destination	Commodity	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
CA	Oakland	Refined Oil Products	$ 909	$ 860	$ 760	$ 972	$ 916
TX	Houston	Refined Oil Products	$ 1,013	$ 968	$ 987	$ 898	$ 916
CA	Los Angeles	Sodium Bicarbonate	$ 640	$ 595	$ 475	$ 762	$ 667
TX	Houston	Sodium Bicarbonate	$ 758	$ 755	$ 773	$ 650	$ 663
CA	Oakland	Fly Ash - DGT	$ 684	$ 639	$ 519	$ 639	$ 544
CA	Sacramento	Fly Ash - DGT	$ 650	$ 605	$ 484	$ 616	$ 501
CA	Oakland	Gilsonite	Railroad-supplied equipment. No lease cost.				
TX	Houston	Gilsonite	Railroad-supplied equipment. No lease cost.				
WI	La Crosse	Frac Sand	$ 475	$ 473	$ 515	$ 463	$ 475
IL	Chicago	Frac Sand	$ 498	$ 495	$ 537	$ 476	$ 489
AL	Birmingham	Steel Pipe	Railroad-supplied equipment. No lease cost.				
IN	Gary	Steel Pipe	Railroad-supplied equipment. No lease cost.				

Red emphasis indicates highest rate, green emphasis indicates lowest rate

4.7 Explanation of the Methodology Used in Determining Rail Equipment Lease Rates

RLBA estimated the total equipment cost per carload of traffic moving over the UBRR destined to thirteen target refineries as a group – so they all have the same five values - because RLBA assumed that the oil marketer (shipper) likely would sell and ship its crude to multiple refineries over the course of a year or years based on changing market conditions. Such an approach would take advantage of the flexibility afforded by rail transportation to switch among multiple markets and would maximize the utilization of its leased tank car fleet. The different equipment utilization rates in each target refinery lane were captured by calculating a weighted average transit time in connection with all thirteen lanes by weighting the transit time in each lane by the annual carloads (high-end) in each lane. With regard to crude oil shipments to the refineries in Salt Lake City, the transits across the four destinations were nearly identical and the projected volumes to each were assumed to be equal, so the same five equipment costs per carload appear regarding each of the four refineries.

The equipment cost per carload for crude oil and frac sand shipments reflect equipment utilization, which results from the faster round-trip transit times afforded by equipment operating in 100-car unit trains, as opposed to single or multiple-car blocks in regular manifest freight trains, where total transit time is inflated as cars are switched into and out of trains headed in the correct direction. Unit train service has been assumed throughout the UBRR operating plan as it typically provides faster transit times and average load-to-load times than does manifest train service. The cars in a unit train remain together during the trip from load-out to refinery and avoid delays associated with being switched from one train to another at intermediate rail yards.

4.8 Determining the 'All-In' Transportation Cost across the National Rail Network

To provide an estimate of the total cost to ship across the national rail system, RLBA combined the estimated freight rates and equipment lease rates developed above into a single value. The application of this methodology yielded the following results as regards crude oil.

Table 4-5
Rail Transportation and Equipment Lease Rate per Carload, Other Commodities; Connection with the National Rail Network - National Markets

			Union Pacific			BNSF Railway	
	Destination	Commodity	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
CA	Oakland	Refined Oil Products	$ 4,673	$ 4,211	$ 3,581	$ 4,931	$ 4,310
TX	Houston	Refined Oil Products	$ 5,415	$ 5,320	$ 5,850	$ 4,974	$ 5,557
CA	Los Angeles	Sodium Bicarbonate	$ 5,174	$ 4,577	$ 3,748	$ 5,556	$ 4,945
TX	Houston	Sodium Bicarbonate	$ 6,652	$ 6,585	$ 7,284	$ 4,376	$ 4,903
CA	Oakland	Fly Ash - DGT	$ 4,578	$ 4,105	$ 3,438	$ 3,812	$ 3,265
CA	Sacramento	Fly Ash - DGT	$ 4,233	$ 3,761	$ 3,093	$ 3,597	$ 3,015
CA	Oakland	Gilsonite	$ 5,122	$ 4,599	$ 3,900	$ 4,102	$ 3,568
TX	Houston	Gilsonite	$ 5,927	$ 5,866	$ 6,512	$ 4,212	$ 4,746
WI	La Crosse	Frac Sand	$ 5,248	$ 5,173	$ 6,279	$ 4,689	$ 5,522
IL	Chicago	Frac Sand	$ 4,988	$ 4,913	$ 6,019	$ 4,488	$ 5,322
AL	Birmingham	Steel Pipe	$ 10,686	$ 10,589	$ 11,605	$ 9,673	$ 10,750
IN	Gary	Steel Pipe	$ 7,767	$ 7,670	$ 8,685	$ 8,416	$ 9,492

**Equipment lease rate included in freight rate*
Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

Table 4-6
Rail Transportation and Equipment Lease Rate per Carload and per Barrel, Crude Oil; Connection with the National Rail Network - National Markets

			Union Pacific			BNSF Railway	
	Destination	Oil Type Customer	Craig, CO	Rifle, CO	Price, UT	Rifle, CO	Price, UT
Per Carload							
LA	Shreveport	Crude - Calumet	$ 4,796	$ 4,736	$ 5,339	$ 4,267	$ 4,801
MS	Pascagoula	Crude - Chevron	$ 5,892	$ 5,832	$ 6,435	$ 5,234	$ 5,766
LA	Baton Rouge	Crude - Exxon Mobil	$ 5,225	$ 5,165	$ 5,768	$ 4,985	$ 5,519
TX	Baytown	Crude - Exxon Mobil	$ 4,550	$ 4,490	$ 5,093	$ 4,000	$ 4,533
KY	Catlettsburg	Crude - Marathon	$ 5,669	$ 5,610	$ 6,460	$ 5,282	$ 5,939
LA	Garyville	Crude - Marathon	$ 6,087	$ 6,027	$ 6,630	$ 5,642	$ 6,173
TX	Galveston Bay	Crude - Marathon	$ 4,589	$ 4,530	$ 5,133	$ 4,020	$ 4,553
WA	Anacortes	Crude - Marathon	$ 5,252	$ 4,775	$ 4,210	$ 4,825	$ 4,325
TX	Port Arthur	Crude - Motiva	$ 4,717	$ 4,657	$ 5,260	$ 4,133	$ 4,665
LA	Norco	Crude - Shell	$ 6,038	$ 5,978	$ 6,581	$ 5,593	$ 6,125
LA	Convent	Crude - Shell	$ 6,131	$ 6,071	$ 6,675	$ 5,686	$ 6,216
TX	Deer Park	Crude - Shell / Pemex	$ 4,466	$ 4,365	$ 4,968	$ 4,211	$ 4,736
TX	Port Arthur	Crude - Valero	$ 4,717	$ 4,657	$ 5,260	$ 4,133	$ 4,665
OK	Cushing	Crude - Transload	$ 3,469	$ 3,409	$ 4,012	$ 3,058	$ 3,592
UT	North Salt Lake	Crude - Big West Oil	$ 1,901	$ 1,384	$ 736	$ 1,404	$ 739
UT	Salt Lake City	Crude - Shevron	$ 1,887	$ 1,370	$ 722	$ 1,388	$ 723
UT	Salt Lake City	Crude - Tesoro	$ 1,887	$ 1,370	$ 722	$ 1,388	$ 723
UT	Woods Cross	Crude - HollyFrontier	$ 1,910	$ 1,393	$ 745	$ 1,415	$ 750
UT	Salt Lake City	Shale - Enefit	$ 4,138	$ 3,269	$ 2,235	$ 3,009	$ 2,073
CA	Los Angeles	Shale - Enefit	$ 7,173	$ 6,354	$ 5,269	$ 7,236	$ 6,308
TX	Houston	Shale - Enefit	$ 6,945	$ 6,967	$ 7,618	$ 5,903	$ 6,516
Per Barrel							
LA	Shreveport	Crude - Calumet	$ 7.49	$ 7.40	$ 8.34	$ 6.67	$ 7.50
MS	Pascagoula	Crude - Chevron	$ 9.21	$ 9.11	$ 10.05	$ 8.18	$ 9.01
LA	Baton Rouge	Crude - Exxon Mobil	$ 8.16	$ 8.07	$ 9.01	$ 7.79	$ 8.62
TX	Baytown	Crude - Exxon Mobil	$ 7.11	$ 7.02	$ 7.96	$ 6.25	$ 7.08
KY	Catlettsburg	Crude - Marathon	$ 8.86	$ 8.77	$ 10.09	$ 8.25	$ 9.28
LA	Garyville	Crude - Marathon	$ 9.51	$ 9.42	$ 10.36	$ 8.82	$ 9.65
TX	Galveston Bay	Crude - Marathon	$ 7.17	$ 7.08	$ 8.02	$ 6.28	$ 7.11
WA	Anacortes	Crude - Marathon	$ 8.21	$ 7.46	$ 6.58	$ 7.54	$ 6.76
TX	Port Arthur	Crude - Motiva	$ 7.37	$ 7.28	$ 8.22	$ 6.46	$ 7.29
LA	Norco	Crude - Shell	$ 9.43	$ 9.34	$ 10.28	$ 8.74	$ 9.57
LA	Convent	Crude - Shell	$ 9.58	$ 9.49	$ 10.43	$ 8.88	$ 9.71
TX	Deer Park	Crude - Shell / Pemex	$ 6.98	$ 6.82	$ 7.76	$ 6.58	$ 7.40
TX	Port Arthur	Crude - Valero	$ 7.37	$ 7.28	$ 8.22	$ 6.46	$ 7.29
OK	Cushing	Crude - Transload	$ 5.42	$ 5.33	$ 6.27	$ 4.78	$ 5.61
UT	North Salt Lake	Crude - Big West Oil	$ 2.97	$ 2.16	$ 1.15	$ 2.19	$ 1.15
UT	Salt Lake City	Crude - Shevron	$ 2.95	$ 2.14	$ 1.13	$ 2.17	$ 1.13
UT	Salt Lake City	Crude - Tesoro	$ 2.95	$ 2.14	$ 1.13	$ 2.17	$ 1.13
UT	Woods Cross	Crude - HollyFrontier	$ 2.98	$ 2.18	$ 1.16	$ 2.21	$ 1.17
UT	Salt Lake City	Shale - Enefit	$ 6.47	$ 5.11	$ 3.49	$ 4.70	$ 3.24
CA	Los Angeles	Shale - Enefit	$ 11.21	$ 9.93	$ 8.23	$ 11.31	$ 9.86
TX	Houston	Shale - Enefit	$ 10.85	$ 10.89	$ 11.90	$ 9.22	$ 10.18

Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

5.0 Conclusion

The following section addresses the ultimate conclusions reached by RLBA.

5.1 Total Rail Cost to Ship Uinta Basin Commodities on the Proposed UBRR

To offer a final opinion regarding what the total transportation cost which prospective Uinta Basin rail shippers might pay to ship via the UBRR between the Myton/Leland Bench, UT Area and national markets, RLBA synthesized the following values, described in detail earlier in this report, including:

1. The average annual break even rate for each of three prospective rail alignments at both the Higher and Lower forecast volumes;
2. The estimated freight rate across the national system to the various, identified destinations; and
3. The estimated equipment lease rates.

This comparison yielded the following results.

Table 5-1
Rail Transportation and Equipment Lease Rate per Carload;
Myton/Leland Bench Area - National Markets
Assuming Lower Volume Forecast

Oil Type/Customer/Location			Union Pacific			BNSF Railway	
Destination		Customer	Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 6,338	$ 6,362	$ 6,064	$ 5,870	$ 5,894
MS	Pascagoula	Crude - Chevron	$ 7,434	$ 7,458	$ 7,160	$ 6,836	$ 6,860
LA	Baton Rouge	Crude - Exxon Mobil	$ 6,767	$ 6,791	$ 6,493	$ 6,587	$ 6,612
TX	Baytown	Crude - Exxon Mobil	$ 6,092	$ 6,116	$ 5,818	$ 5,602	$ 5,627
KY	Catlettsburg	Crude - Marathon	$ 7,212	$ 7,236	$ 6,937	$ 6,884	$ 6,908
LA	Garyville	Crude - Marathon	$ 7,629	$ 7,653	$ 7,355	$ 7,244	$ 7,269
TX	Galveston Bay	Crude - Marathon	$ 6,132	$ 6,156	$ 5,857	$ 5,622	$ 5,646
WA	Anacortes	Crude - Marathon	$ 6,377	$ 6,401	$ 6,520	$ 6,427	$ 6,451
TX	Port Arthur	Crude - Motiva	$ 6,259	$ 6,283	$ 5,985	$ 5,735	$ 5,759
LA	Norco	Crude - Shell	$ 7,580	$ 7,604	$ 7,306	$ 7,196	$ 7,220
LA	Convent	Crude - Shell	$ 7,673	$ 7,697	$ 7,399	$ 7,288	$ 7,312
TX	Deer Park	Crude - Shell / Pemex	$ 5,967	$ 5,991	$ 5,734	$ 5,814	$ 5,838
TX	Port Arthur	Crude - Valero	$ 6,259	$ 6,283	$ 5,985	$ 5,735	$ 5,759
OK	Cushing	Crude - Transload	$ 5,011	$ 5,035	$ 4,737	$ 4,660	$ 4,684
UT	North Salt Lake	Crude - Big West Oil	$ 2,986	$ 3,010	$ 3,169	$ 3,006	$ 3,030
UT	Salt Lake City	Crude - Chevron	$ 2,972	$ 2,996	$ 3,155	$ 2,990	$ 3,014
UT	Salt Lake City	Crude - Tesoro	$ 2,972	$ 2,996	$ 3,155	$ 2,990	$ 3,014
UT	Woods Cross	Crude - HollyFrontier	$ 2,995	$ 3,019	$ 3,178	$ 3,017	$ 3,041
UT	Salt Lake City	Shale - Enefit	$ 4,871	$ 4,895	$ 5,406	$ 4,611	$ 4,636
CA	Los Angeles	Shale - Enefit	$ 7,956	$ 7,980	$ 8,441	$ 8,838	$ 8,862
TX	Houston	Shale - Enefit	$ 8,569	$ 8,593	$ 8,213	$ 7,505	$ 7,530

Other Commodities			Union Pacific			BNSF Railway	
Destination		Commodity	Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
CA	Oakland	Refined Oil Products	$ 5,813	$ 5,837	$ 5,941	$ 6,533	$ 6,558
TX	Houston	Refined Oil Products	$ 6,922	$ 6,946	$ 6,683	$ 6,576	$ 6,600
CA	Los Angeles	Sodium Bicarbonate	$ 6,179	$ 6,203	$ 6,442	$ 7,158	$ 7,182
TX	Houston	Sodium Bicarbonate	$ 8,187	$ 8,211	$ 7,920	$ 5,978	$ 6,002
CA	Oakland	Fly Ash - DGT	$ 5,707	$ 5,732	$ 5,846	$ 5,415	$ 5,439
CA	Sacramento	Fly Ash - DGT	$ 5,363	$ 5,387	$ 5,501	$ 5,199	$ 5,223
CA	Oakland	Gilsonite*	$ 6,201	$ 6,226	$ 6,390	$ 5,704	$ 5,728
TX	Houston	Gilsonite*	$ 7,468	$ 7,493	$ 7,195	$ 5,814	$ 5,839
WI	La Crosse	Frac Sand	$ 6,775	$ 6,799	$ 6,516	$ 6,291	$ 6,315
IL	Chicago	Frac Sand	$ 6,515	$ 6,539	$ 6,255	$ 6,090	$ 6,115
AL	Birmingham	Steel Pipe*	$ 12,191	$ 12,215	$ 11,954	$ 11,275	$ 11,299
IN	Gary	Steel Pipe*	$ 9,272	$ 9,296	$ 9,035	$ 10,018	$ 10,042

**Equipment lease rate included in freight rate*
Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

Table 5-2
Rail Transportation and Equipment Lease Rate per Carload;
Myton/Leland Bench Area - National Markets
Assuming Higher Volume Forecast

Oil Type/Customer/Location			Union Pacific			BNSF Railway	
Destination		Customer	Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 5,763	$ 5,782	$ 5,614	$ 5,295	$ 5,314
MS	Pascagoula	Crude - Chevron	$ 6,859	$ 6,878	$ 6,710	$ 6,261	$ 6,280
LA	Baton Rouge	Crude - Exxon Mobil	$ 6,192	$ 6,211	$ 6,043	$ 6,012	$ 6,031
TX	Baytown	Crude - Exxon Mobil	$ 5,517	$ 5,536	$ 5,368	$ 5,027	$ 5,046
KY	Catlettsburg	Crude - Marathon	$ 6,637	$ 6,656	$ 6,487	$ 6,309	$ 6,328
LA	Garyville	Crude - Marathon	$ 7,054	$ 7,073	$ 6,905	$ 6,670	$ 6,688
TX	Galveston Bay	Crude - Marathon	$ 5,557	$ 5,576	$ 5,407	$ 5,047	$ 5,066
WA	Anacortes	Crude - Marathon	$ 5,802	$ 5,821	$ 6,070	$ 5,852	$ 5,871
TX	Port Arthur	Crude - Motiva	$ 5,684	$ 5,703	$ 5,535	$ 5,160	$ 5,179
LA	Norco	Crude - Shell	$ 7,005	$ 7,024	$ 6,856	$ 6,621	$ 6,640
LA	Convent	Crude - Shell	$ 7,098	$ 7,117	$ 6,949	$ 6,713	$ 6,732
TX	Deer Park	Crude - Shell / Pemex	$ 5,392	$ 5,411	$ 5,284	$ 5,239	$ 5,258
TX	Port Arthur	Crude - Valero	$ 5,684	$ 5,703	$ 5,535	$ 5,160	$ 5,179
OK	Cushing	Crude - Transload	$ 4,436	$ 4,455	$ 4,287	$ 4,085	$ 4,104
UT	North Salt Lake	Crude - Big West Oil	$ 2,411	$ 2,430	$ 2,719	$ 2,431	$ 2,450
UT	Salt Lake City	Crude - Chevron	$ 2,397	$ 2,416	$ 2,705	$ 2,415	$ 2,434
UT	Salt Lake City	Crude - Tesoro	$ 2,397	$ 2,416	$ 2,705	$ 2,415	$ 2,434
UT	Woods Cross	Crude - HollyFrontier	$ 2,420	$ 2,439	$ 2,728	$ 2,442	$ 2,461
UT	Salt Lake City	Shale - Enefit	$ 4,296	$ 4,315	$ 4,956	$ 4,037	$ 4,055
CA	Los Angeles	Shale - Enefit	$ 6,356	$ 7,400	$ 7,991	$ 8,263	$ 8,282
TX	Houston	Shale - Enefit	$ 6,967	$ 8,013	$ 7,763	$ 6,931	$ 6,949

Other Commodities			Union Pacific			BNSF Railway	
Destination		Commodity	Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
CA	Oakland	Refined Oil Products	$ 4,211	$ 5,257	$ 5,491	$ 5,958	$ 5,977
TX	Houston	Refined Oil Products	$ 5,320	$ 6,366	$ 6,233	$ 6,001	$ 6,020
CA	Los Angeles	Sodium Bicarbonate	$ 4,577	$ 5,623	$ 5,992	$ 6,583	$ 6,602
TX	Houston	Sodium Bicarbonate	$ 6,585	$ 7,631	$ 7,470	$ 5,403	$ 5,422
CA	Oakland	Fly Ash - DGT	$ 4,105	$ 5,151	$ 5,396	$ 4,840	$ 4,859
CA	Sacramento	Fly Ash - DGT	$ 3,761	$ 4,807	$ 5,051	$ 4,624	$ 4,643
CA	Oakland	Gilsonite*	$ 4,599	$ 5,645	$ 5,940	$ 5,129	$ 5,148
TX	Houston	Gilsonite*	$ 5,866	$ 6,912	$ 6,745	$ 5,239	$ 5,258
WI	La Crosse	Frac Sand	$ 5,173	$ 6,219	$ 6,066	$ 5,716	$ 5,735
IL	Chicago	Frac Sand	$ 4,913	$ 5,959	$ 5,805	$ 5,515	$ 5,534
AL	Birmingham	Steel Pipe*	$ 10,589	$ 11,635	$ 11,504	$ 10,700	$ 10,719
IN	Gary	Steel Pipe*	$ 7,670	$ 8,716	$ 8,585	$ 9,443	$ 9,462

**Equipment lease rate included in freight rate*
Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

Table 5-3
Rail Transportation and Equipment Lease Rate per Barrel, Crude Oil; Myton/Leland Bench Area - National Markets
Lower and Higher Volume Forecasts

Lower

	Destination	Customer	Union Pacific			BNSF Railway	
			Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 9.90	$ 9.94	$ 9.47	$ 9.17	$ 9.21
MS	Pascagoula	Crude - Chevron	$ 11.62	$ 11.65	$ 11.19	$ 10.68	$ 10.72
LA	Baton Rouge	Crude - Exxon Mobil	$ 10.57	$ 10.61	$ 10.14	$ 10.29	$ 10.33
TX	Baytown	Crude - Exxon Mobil	$ 9.52	$ 9.56	$ 9.09	$ 8.75	$ 8.79
KY	Catlettsburg	Crude - Marathon	$ 11.27	$ 11.31	$ 10.84	$ 10.76	$ 10.79
LA	Garyville	Crude - Marathon	$ 11.92	$ 11.96	$ 11.49	$ 11.32	$ 11.36
TX	Galveston Bay	Crude - Marathon	$ 9.58	$ 9.62	$ 9.15	$ 8.78	$ 8.82
WA	Anacortes	Crude - Marathon	$ 9.96	$ 10.00	$ 10.19	$ 10.04	$ 10.08
TX	Port Arthur	Crude - Motiva	$ 9.78	$ 9.82	$ 9.35	$ 8.96	$ 9.00
LA	Norco	Crude - Shell	$ 11.84	$ 11.88	$ 11.42	$ 11.24	$ 11.28
LA	Convent	Crude - Shell	$ 11.99	$ 12.03	$ 11.56	$ 11.39	$ 11.43
TX	Deer Park	Crude - Shell / Pemex	$ 9.32	$ 9.36	$ 8.96	$ 9.08	$ 9.12
TX	Port Arthur	Crude - Valero	$ 9.78	$ 9.82	$ 9.35	$ 8.96	$ 9.00
OK	Cushing	Crude - Transload	$ 7.83	$ 7.87	$ 7.40	$ 7.28	$ 7.32
UT	North Salt Lake	Crude - Big West Oil	$ 4.67	$ 4.70	$ 4.95	$ 4.70	$ 4.74
UT	Salt Lake City	Crude - Chevron	$ 4.64	$ 4.68	$ 4.93	$ 4.67	$ 4.71
UT	Salt Lake City	Crude - Tesoro	$ 4.64	$ 4.68	$ 4.93	$ 4.67	$ 4.71
UT	Woods Cross	Crude - HollyFrontier	$ 4.68	$ 4.72	$ 4.97	$ 4.71	$ 4.75
UT	Salt Lake City	Shale - Enefit	$ 7.61	$ 7.65	$ 8.45	$ 7.21	$ 7.24
CA	Los Angeles	Shale - Enefit	$ 12.43	$ 12.47	$ 13.19	$ 13.81	$ 13.85
TX	Houston	Shale - Enefit	$ 13.39	$ 13.43	$ 12.83	$ 11.73	$ 11.77

Higher

	Destination	Customer	Union Pacific			BNSF Railway	
			Rifle via Meeker	Rifle via Piceance	Craig	Rifle via Meeker	Rifle via Piceance
LA	Shreveport	Crude - Calumet	$ 9.01	$ 9.03	$ 8.77	$ 8.27	$ 8.30
MS	Pascagoula	Crude - Chevron	$ 10.72	$ 10.75	$ 10.48	$ 9.78	$ 9.81
LA	Baton Rouge	Crude - Exxon Mobil	$ 9.68	$ 9.70	$ 9.44	$ 9.39	$ 9.42
TX	Baytown	Crude - Exxon Mobil	$ 8.62	$ 8.65	$ 8.39	$ 7.86	$ 7.88
KY	Catlettsburg	Crude - Marathon	$ 10.37	$ 10.40	$ 10.14	$ 9.86	$ 9.89
LA	Garyville	Crude - Marathon	$ 11.02	$ 11.05	$ 10.79	$ 10.42	$ 10.45
TX	Galveston Bay	Crude - Marathon	$ 8.68	$ 8.71	$ 8.45	$ 7.89	$ 7.92
WA	Anacortes	Crude - Marathon	$ 9.07	$ 9.10	$ 9.48	$ 9.14	$ 9.17
TX	Port Arthur	Crude - Motiva	$ 8.88	$ 8.91	$ 8.65	$ 8.06	$ 8.09
LA	Norco	Crude - Shell	$ 10.95	$ 10.98	$ 10.71	$ 10.34	$ 10.37
LA	Convent	Crude - Shell	$ 11.09	$ 11.12	$ 10.86	$ 10.49	$ 10.52
TX	Deer Park	Crude - Shell / Pemex	$ 8.43	$ 8.45	$ 8.26	$ 8.19	$ 8.22
TX	Port Arthur	Crude - Valero	$ 8.88	$ 8.91	$ 8.65	$ 8.06	$ 8.09
OK	Cushing	Crude - Transload	$ 6.93	$ 6.96	$ 6.70	$ 6.38	$ 6.41
UT	North Salt Lake	Crude - Big West Oil	$ 3.77	$ 3.80	$ 4.25	$ 3.80	$ 3.83
UT	Salt Lake City	Crude - Chevron	$ 3.75	$ 3.78	$ 4.23	$ 3.77	$ 3.80
UT	Salt Lake City	Crude - Tesoro	$ 3.75	$ 3.78	$ 4.23	$ 3.77	$ 3.80
UT	Woods Cross	Crude - HollyFrontier	$ 3.78	$ 3.81	$ 4.26	$ 3.82	$ 3.85
UT	Salt Lake City	Shale - Enefit	$ 6.71	$ 6.74	$ 7.74	$ 6.31	$ 6.34
CA	Los Angeles	Shale - Enefit	$ 9.93	$ 11.56	$ 12.49	$ 12.91	$ 12.94
TX	Houston	Shale - Enefit	$ 10.89	$ 12.52	$ 12.13	$ 10.83	$ 10.86

Red highlight indicates the highest rate and green, the lowest rate, to each destination listed above

RLBA's analysis suggests the following conclusions:

1. Assuming the Higher forecast volume, the Rifle via Meeker alignment, allowing for interchange with both UP and BNSF, offers prospective Uinta Basin rail shippers the lowest total rail transportation cost on all 33 identified shipping lanes;

2. Assuming the Higher forecast volume, the Rifle via Piceance Creek alignment, allowing for interchange with both UP and BNSF, offers prospective Uinta Basin rail shippers the highest cost on 25 of the 33 identified shipping lanes (76%);

3. Assuming the Higher forecast volume, the Craig alignment, allowing for interchange with UP, offers prospective Uinta Basin rail shippers the highest cost on 8 of the 33 identified shipping lanes (24%);

4. Assuming the Lower forecast volume, the Rifle via Meeker alignment, allowing for interchange with both UP and BNSF, offers prospective Uinta Basin rail shippers the lowest total rail transportation cost on 30 of the 33 identified shipping lanes (90%);

5. Assuming the Lower forecast volume, the Rifle via Piceance Creek alignment, allowing for interchange with either UP or BNSF, offers prospective Uinta Basin rail shippers the highest cost on 24 of the 33 identified shipping lanes (73%) and

6. Assuming the Lower forecast volume, the Craig alignment, allowing for interchange with UP, offers prospective Uinta Basin rail shippers the lowest cost on 3 of the 33 identified shipping lanes (10%) and the highest cost on 9 of the 33 identified shipping lanes.

Given that the ultimate goal of the UBRR is to provide prospective Uinta Basin rail shippers with the lowest cost transportation option between the Uinta Basin and national markets, it would appear that the Rifle via Meeker Area rail alignment would be the most prudent selection.

5.2 Recommendations

1. **Volumes** - To reiterate the importance and impact of the four challenges described earlier, the viability and competitiveness of the prospective railroad is directly related to the volumes of traffic which would be shipped over the line.

2. **Feasibility of the Proposed Railroad** - Assuming the forecasted volumes can be achieved, it appears that the proposed railroad can offer cost competitive transportation to prospective Uinta Basin rail shippers, as compared with the most practical identified transport alternatives. Beyond the immediate quantifiable monetary benefits, the proposed railroad also would offer more flexibility to transport into and out of the Uinta Basin secondary and tertiary commodities related to both crude oil extraction and other industries.

3. **Multiple Class One Connections** - The Class One rate estimation work conducted by RLBA suggests that the additional construction costs necessary to reach Rifle, CO may be justified by the savings potentially realized by prospective Uinta Basin rail shippers due to the advantages of being: 1) a shorter length of haul, and 2) served by two Class One carriers instead of being 'captive' to one. To this point, RLBA estimates that BNSF, a "second" Class One reached via a connection at Rifle, CO, in general, may offer lower rates to and from the distant locations which are markets for Uinta Basin commodities and sources of commodities consumed in the Uinta Basin. Furthermore, prospective Uinta Basin rail shippers might be able to leverage the two Class Ones against one another in negotiations to receive even more favorable rates than those estimated by RLBA. Similarly, shippers should be able to secure better service than would be the case if only one of those railroads provided service.

4. **Alignment Selection** - While the Craig rail alignment appears to be significantly less costly to construct and operate than either Rifle alignment, the Craig alignment: 1) is generally farther from the markets for Uinta Basin commodities; 2) lacks a second Class One connection; and 3) is located at the end of relatively isolated Union Pacific branch line. As a result, the total rail transportation cost, the sum of the cost to reach the national rail network and then to ship over the national rail network to prospective Uinta Basin rail shippers ultimately would likely be higher using the Craig rail alignment, both to distant markets and Salt Lake City. As such, if the ultimate goal of constructing the prospective railroad is to advance the economic development of the Uinta Basin, it would appear as though the Rifle via Meeker Area rail alignment would be the most prudent selection.

5. **Salt Lake City** - The short length of haul (by rail standards) to Salt Lake City makes an all-rail transportation option utilizing a combination of the prospective railroad and a Class One intrinsically less competitive than shipments to/from more distant markets, though potentially still feasible. If the prospective railroad can obtain or even approach the Higher forecast volumes, the economies of scale are such that rail may be the most cost competitive option. If the Higher forecast volumes cannot be achieved or approached, the Salt Lake City market may not be competitive for rail. In either case, as regards the prospective railroad, RLBA would consider Salt Lake City to be a secondary market to the more distant markets.

EXHIBIT 44

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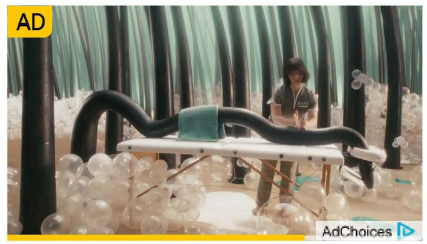
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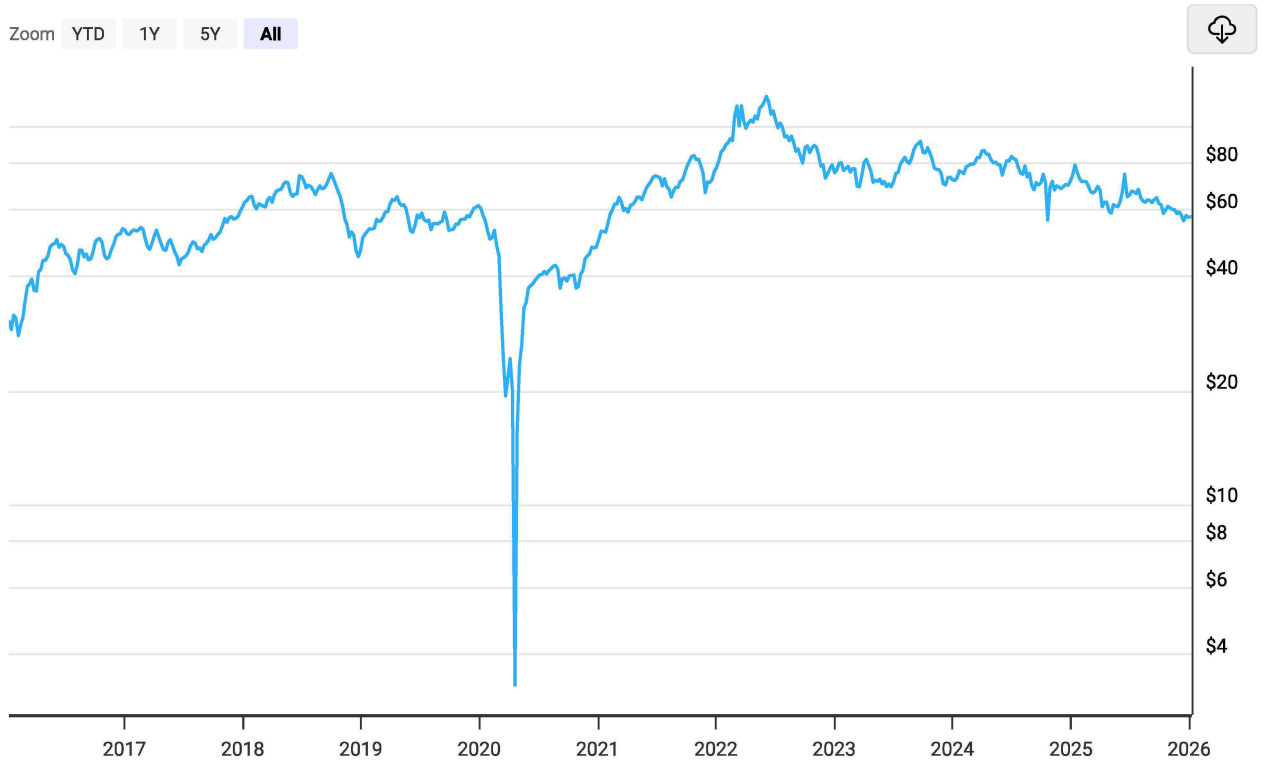
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10 Year Daily Chart

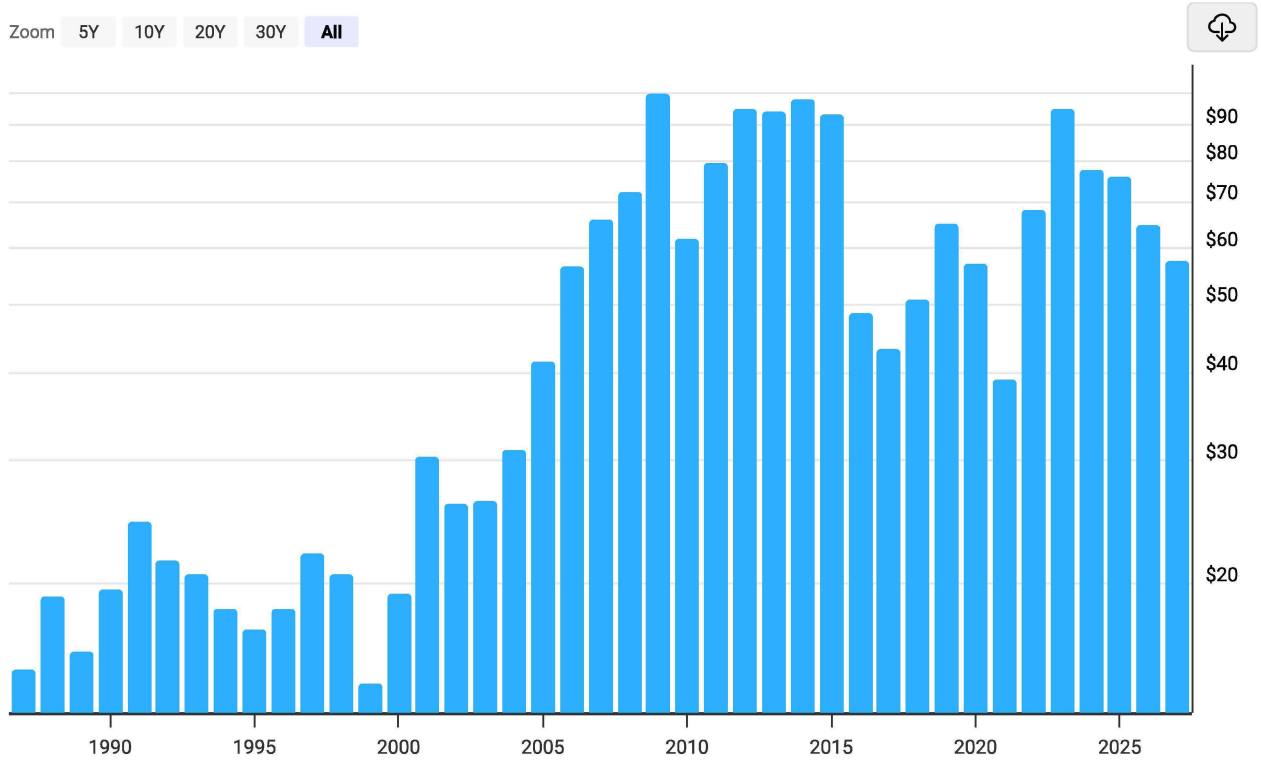




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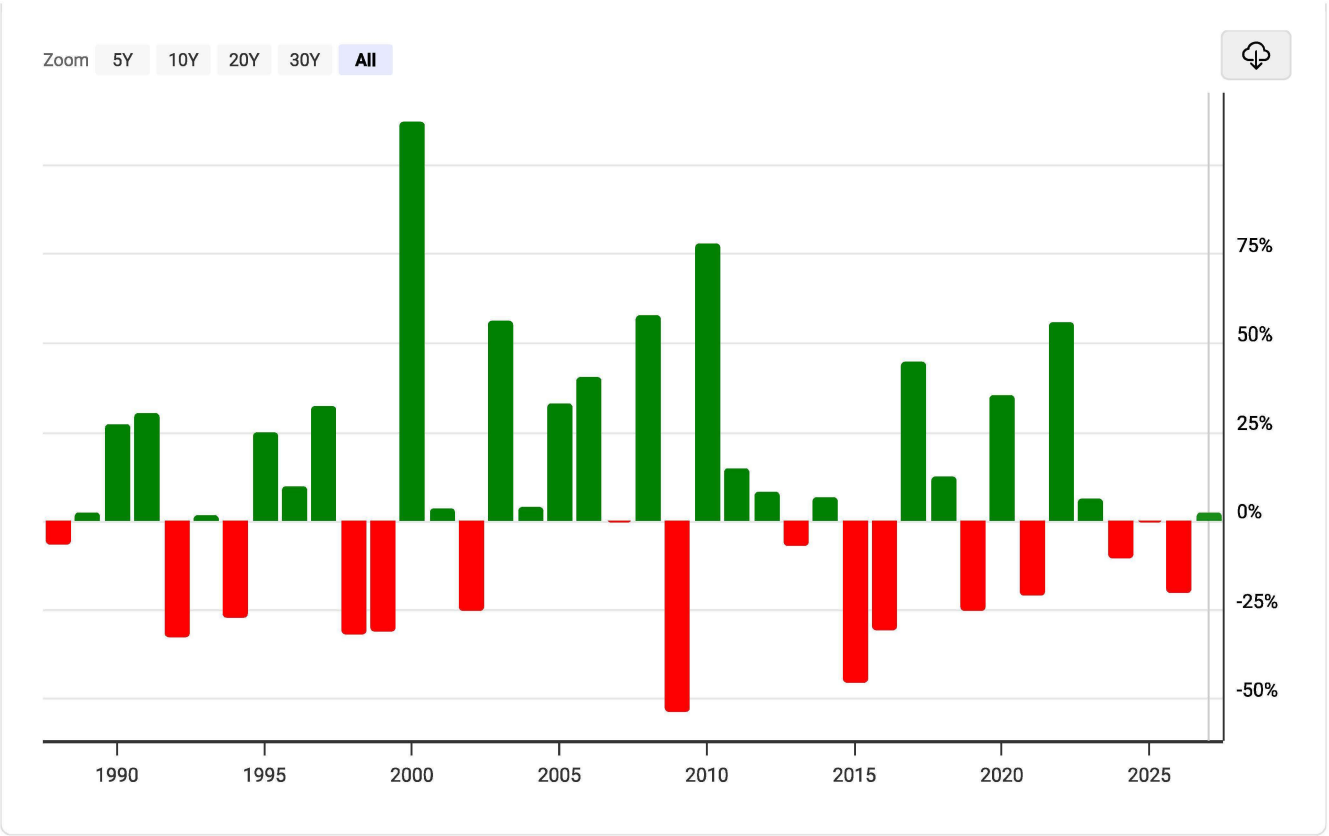
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EXHIBIT 45

The Utah Petroleum Association's (UPA) position on the Uinta Basin Railway project

We seek to promote the responsible development of Utah's vast natural resources and the manufacture of fuels that keep Utah families and businesses moving. UPA recognizes that increased takeaway capacity is crucial to our industry's ability to grow, and rail infrastructure is regionally beneficial.

- UPA supports infrastructure projects that seek to promote Utah's natural resource and energy sectors.
- Neither UPA nor its member companies are involved in the new financing effort for this private venture to tap into public bonding.
- If constructed, the Uinta Basin Railway will add another transportation alternative to the existing options, the terms and conditions of which will be competitively evaluated against existing transportation options.
- The major producers cannot commit to rail yellow and black wax on the Uinta Basin Railway unless the project is able to compete financially with existing transportation alternatives already being utilized by the industry and must not result in increased gasoline prices for consumers.
- If the Uinta Basin Railway is to exist, it must not be solely dependent upon transportation of crude oil. Rail is a critical component of our economy, serving a multitude of industries, and therefore this project should drive more broad economic development.

The Utah Petroleum Association (UPA) is comprised of companies from every segment of the petroleum industry who work cooperatively to resolve mutual problems and provide a unified voice for the advancement and improvement of the oil and gas industry in Utah. UPA was founded in 1958 and continues today as the voice of Utah's oil and natural gas industries.

Please direct any inquiries to UPA Communications Lead Jon Ekstrom: jon@deftcom.us.

EXHIBIT 46

UPA Statement On The Supreme Court's 8-0 Decision to Approve the Uinta Basin Railway in Ruling of Seven County Infrastructure Coalition v Eagle County, Colo.

Utah Petroleum Association is heartened by the Supreme Court's unanimous ruling regarding the Uinta Basin Railway. The ruling affirms that environmental reviews under the National Environmental Policy Act (NEPA) must be limited in scope and consistently applied. Infrastructure and energy projects are often multi-year efforts spanning administrations and political shifts. Whether building a pipeline, a road, or a wind farm, every project deserves a permitting process with clear timelines and scope, instead of unlimited and unreasonable analysis of indirect impacts and endless litigation.

UPA and its member companies are not involved in the permitting, financing, legal or business development efforts of the Seven County Infrastructure Coalition for the Uinta Basin Railway project. If fully permitted, financed, and constructed, the Uinta Basin Railway will add another potential transport option to the existing ample rail options along with other rail projects that have also been announced. Industry's potential use will be determined by the Railway's economics in the competitive free market.

UPA recognizes that increased takeaway capacity is crucial to our industry's ability to grow, and rail infrastructure is regionally beneficial and a matter of national security. This has been buoyed by recent takeaway expansion announcements by Wildcat Midstream at their Helper terminal and by Savage at their Wellington location.

The Utah Petroleum Association (UPA) is comprised of companies from every segment of the petroleum industry who work cooperatively to resolve mutual problems and provide a unified voice for the advancement and improvement of the oil and gas industry in Utah. UPA was founded in 1958 and continues today as the voice of Utah's oil and natural gas industries. Please direct any inquiries to UPA Communications Lead Jon Ekstrom: jekstrom@utahpetroleum.org.

EXHIBIT 47

Utah’s hope for oil shale as a viable energy source is dealt another blow

An Estonian firm withdraws its energy leases in eastern Utah, and environmentalists cheer.

By Tim Fitzpatrick

The Salt Lake Tribune

| Sep. 13, 2023, 6:00 a.m.

| Updated: 9:30 a.m.

https://www.sltrib.com/news/environment/2023/09/13/estonian-company-gives-up-eastern/



Scott Sommerdorf | The Salt Lake Tribune In this 2013 photo, Enefit mining engineer Ben France gestures towards the darker, "mahogany zone" of the oil shale deposit revealed in a "box cut" on the company's private holdings in eastern Uinta County. Enefit recently relinquished its federal oil shale leases in the region, although it continues to own private land and state leases with shale deposits.

Estonian company Enefit is giving up its federal oil shale leases in eastern Utah, signaling once again that Utah shale may never overcome the obstacles to becoming a commercial source of energy.

Enefit in August notified the U.S. Bureau of Land Management's Vernal office that it intends to relinquish its leases, and it proposed a reclamation plan to mitigate the impacts of its work there.

"Upon extensive consideration of business plans regarding federal oil shale leasing and development, EAO has elected not to prepare an application to BLM to trigger the conversion process from the RD&D Lease to a commercial lease, and thus is voluntarily relinquishing the RD&D Lease," wrote Ryan Clerico, Chief Executive Officer Enefit American Oil, in an August 9 letter.

The withdrawal came as the Grand Canyon Trust and the owners of the Bonanza coal-fired power plant near Vernal entered into a settlement agreement regarding water rights that may have gone to the Enefit project. Oil shale is essentially petroleum embedded in sedimentary rock. Separating the petroleum from the rock makes it more difficult and water-intensive than traditional oil drilling.

Under that agreement, Deseret Generation and Transmission, owners of the Bonanza plant, agreed to not use the water rights it obtained from Enefit for any kind of fossil-fuel production.

Deseret had obtained the rights from Enefit for a mere $10, and the Grand Canyon Trust challenged that transfer. Because Enefit had not developed a commercial oil shale operation that would require the water, it risked losing the right under "use it or lose it" water laws. Environmentalists viewed the sale to Deseret as a dodge of use-it-or-lose-it laws, although Deseret maintained it intended to use the water for its own projects.

"The good news is that the Bush-Cheney nightmare vision of strip mining thousands of acres of wildlife habitat on public lands to produce the most carbon-polluting gasoline in the world appears to finally be ending," said Ted Zukoski, senior attorney at the Center for Biological Diversity, in a statement on Enefit's lease relinquishment. "Enefit was the last company holding an oil shale research lease on BLM land that hadn't expired or been relinquished."

Environmental groups cheer Enefit's move

The Natural Resources Defense Council, the Southern Utah Wilderness Alliance, Utah Physicians for a Healthy Environment, Earthjustice and Waterkeeper Alliance all issued statements cheering Enefit's decision.

Michael Vanden Berg, energy and minerals program manager for the Utah Geological Survey, confirmed that Enefit's was the last "RD&D" oil shale lease in Utah. Those leases

differ from regular oil leases in that they aimed at unconventional sources like shale that need more research and development to become a commercial source. At one time Exxon, Chevron, Shell and others also had RD&D shale leases, but all have been abandoned.

Other companies still hold shale leases from the state Trust Land Administration, but no shale operations are under development on those lands.

Vanden Berg said shale looked promising back in 2006 when oil prices shot up, and interest persisted until oil prices dropped again around 2014. By that point, Vanden Berg said, new techniques like fracking and horizontal drilling had come to dominate oil production, and shale projects were put on the back burner. “That just became dominant. Major companies dropped their RD&D leases.”

Vanden Berg noted that Enefit still has significant oil shale holdings in Utah even after giving up the federal leases. Those include private lands and leases from the state Trust Land Administration, and those shale deposits are closer to the surface than on the federal lands, which theoretically makes them easier to commercialize. “Giving up the BLM lease is really not that big of a deal,” he said, although he said all the challenges to shale development remain.

In an email, Clerico said the company is looking at options for its private holdings. “EAO is currently evaluating a number of different business cases, including some that are unrelated to oil shale. For example, EAO commissioned a conceptual study for a utility-scale solar power project in the recent past, and we have considered combined solar, wind and energy storage layouts on our private land.”

He added, “There is no active development or construction on the property, but there are also no definitive or imminent plans to terminate our operations in the U.S.”

The settlement around water rights could be a major deterrent to developing the oil shale deposits. In all scenarios, a commercial shale operation would require large amounts of water.

Before the settlement agreement, Deseret Generation and Transmission could use the water rights it obtained from Enefit for irrigation, domestic and industrial use and mining, including oil shale. Under the settlement, the only allowable use is for the Bonanza plant.

Coal-fired power plants, which use steam power, require large amounts of water. Under a previous legal settlement, Bonanza is only allowed to produce a certain amount of coal emissions before it must close. The plant is a main source of power for rural electric cooperatives in and around Utah, and Deseret has been looking at options for trying to extend its life.

One of those options could be carbon capture, which involves capturing the climate-damaging carbon dioxide from the plant’s smokestack and sequestering it underground.

The University of Utah has a grant to study carbon capture possibilities in the Uinta Basin. There are no coal-fired power plants with carbon capture operating in the U.S.

A separate U. of U. study looked at the water demands of various energy sources, and it found that adding carbon capture to coal-fired plants almost doubled the amount of water required. It also turns coal into one of the most expensive energy sources.

EXHIBIT 48

Eesti Energia to wrap up its US business



Eesti Energia logo. Source: Siim Lõvi/ERR

NEWS

Johannes Voltri
29.01.2024 05:54

Estonia's national energy company Eesti Energia has decided to wrap up its business activity in the United States. The company owns land and rights to 3.5 billion tons of oil shale in the state of Utah, which it estimates could take around a year to sell.

Finance Minister Mart Võrklaev (Reform) last week approved a decision taken at Eesti Energia to liquidate four of the group's U.S. businesses. They are the EAO Orion LLC, EAO Technology LLC, EAO State Leases LLC and EAO Federal Lease LLC.

Eesti Energia board member Raine Pajo said that the companies are not valuable in themselves, while their liquidation if part of a wider process.

"Our plan is to wrap up business activity in the USA. The companies used to hold land or license rights and there were costs associated with maintaining them. We are reorganizing our structure to end this and avoid confusion." Pajo said.

Around a decade ago, Eesti Energia had plans for developing the oil shale industry in Utah. The company said in a press release from that period that it wanted to reach an output of 57,000 barrels of shale oil per day.

Minister Võrklaev described Eesti Energia's American venture as neither profitable nor promising.



Low electricity price behind Enefit Power layoffs

"I commend the current board of the company for critically revisiting past ventures, and, unfortunately, we can see that a mistake has been made. While no one is infallible, the mistakes numbered quite a few, so we are seeing unnecessary and unpromising projects being wrapped up to get expenses back under control and concentrate more on the main business," Võrklaev said.

Eesti Energia will retain for the time being the Enefit American Oil Corporation that employs one full-time and one half-time employee and its subsidiary Real Estate Corporation. The latter owns the land and oil shale resource in Utah. The company owns three plots totaling a few hundred square kilometers and holding an estimated 3.5 billion tons of oil shale.

Pajo said that Eesti Energia's USA project is worth €31 million. The loss the company is looking at remains unknown at this time.

"It depends on our exit, how the sale will go. The process could take about a year, which is when we'll know more," the remarked.

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Editor: Mirjam Mäekivi, Marcus Turovski

eesti energia | oil shale | usa | utah

EXHIBIT 49

UTAH MINING 2024

METALS, INDUSTRIAL MINERALS, URANIUM, AND COAL

by Stephanie E. Mills, Andrew Rupke, Michael D. Vanden Berg, and Taylor Boden



CIRCULAR 139
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2025

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UTAH MINING 2024

METALS, INDUSTRIAL MINERALS, URANIUM, AND COAL

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Cover photo: *Blue and green copper mineralization on the Niagara Cut at the Milford copper mine in Beaver County.*

Suggested citation:

Mills, S.E., Rupke, A., Vanden Berg, M.D., and Boden, T., 2025, Utah mining 2024—Metals, industrial minerals, uranium, and coal: Utah Geological Survey Circular 139, 26 p., https://doi.org/10.34191/c-139.



CIRCULAR 139
UTAH GEOLOGICAL SURVEY
UTAH DEPARTMENT OF NATURAL RESOURCES
2025

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UTAH MINING 2024

METALS, INDUSTRIAL MINERALS, URANIUM, AND COAL

by Stephanie E. Mills, Andrew Rupke, Michael D. Vanden Berg, and Taylor Boden

INTRODUCTION

2024 Utah Mining Industry Summary

The estimated combined value of Utah's extractive resource production in 2024 totaled approximately $9.5 billion, including production of metals and industrial minerals ($4.0 billion), natural gas and natural gas liquids ($896 million), crude oil ($4.1 billion), uranium ($13 million), and coal ($504 million) (Figure 1). Utah's diverse mining industry (metals, industrial minerals, uranium, and coal) accounted for $4.5 billion (47%) of total extractive resource production, an increase of $226 million from the 2023 revised value (nominal dollars), but lower than peak values reached in 2011 ($5.3 billion, nominal dollars). Mining activities in Utah currently produce base metals, precious metals, industrial minerals, and coal (Figure 2). Utah also hosts significant mineral processing facilities, though these are not mines and therefore not counted within the production values of this report. These facilities include: the only conventional uranium mill in the U.S., which can also process vanadium ore to produce vanadium pentoxide and monazite ore to produce intermediate rare earth products; one of only two copper smelters in the U.S.; and a custom beryllium mill supporting the largest global producer of beryllium.

Metallic minerals accounted for $2.1 billion in production value and copper alone accounted for nearly 60% ($1.2 billion) of Utah's metal production value. Base metal production contributed $1.9 billion and included copper, beryllium, molybdenum, and iron (Figure 3). Precious metals produced in Utah include gold and silver, and 2024 production was valued at nearly $270 million (Figure 3).

Industrial minerals produced in Utah include sand and gravel, crushed stone, salt, potash, cement, lime, phosphate, uintaite (Gilsonite®), clay, gypsum, and other commodities (Figure 2). The estimated value of industrial mineral production in 2024 was $1.9 billion (Figure 3), a 2.8% reduction over the revised 2023 estimate. The most valuable industrial mineral group in 2024, estimated at $650 million, was the construction material commodity group which includes sand and gravel, crushed stone, and dimension stone. The value of Utah coal production increased by 61% in 2024 to $504 million as a function of higher production and a significant increase in average price (Figure 3).

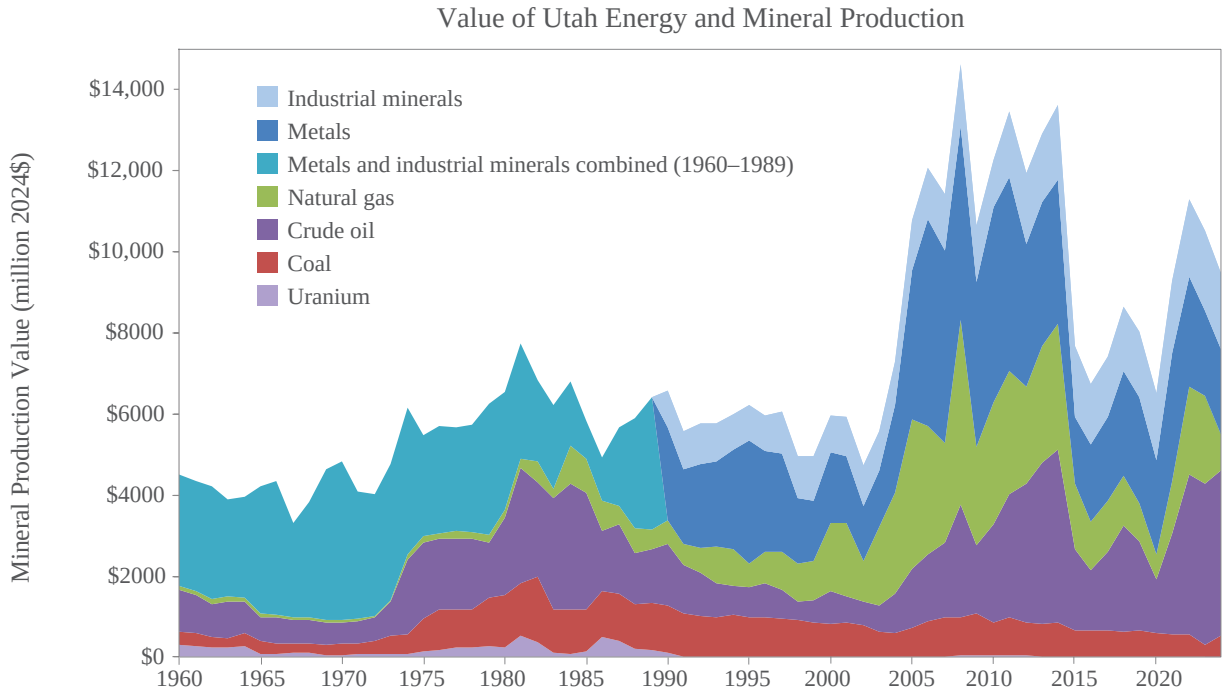


Figure 1. *Annual value of Utah energy and mineral production, inflation adjusted to 2024 dollars, 1960–2024. Source: Utah Geological Survey; U.S. Geological Survey; Utah Division of Oil, Gas and Mining; U.S. Energy Information Administration; Utah Tax Commission.*

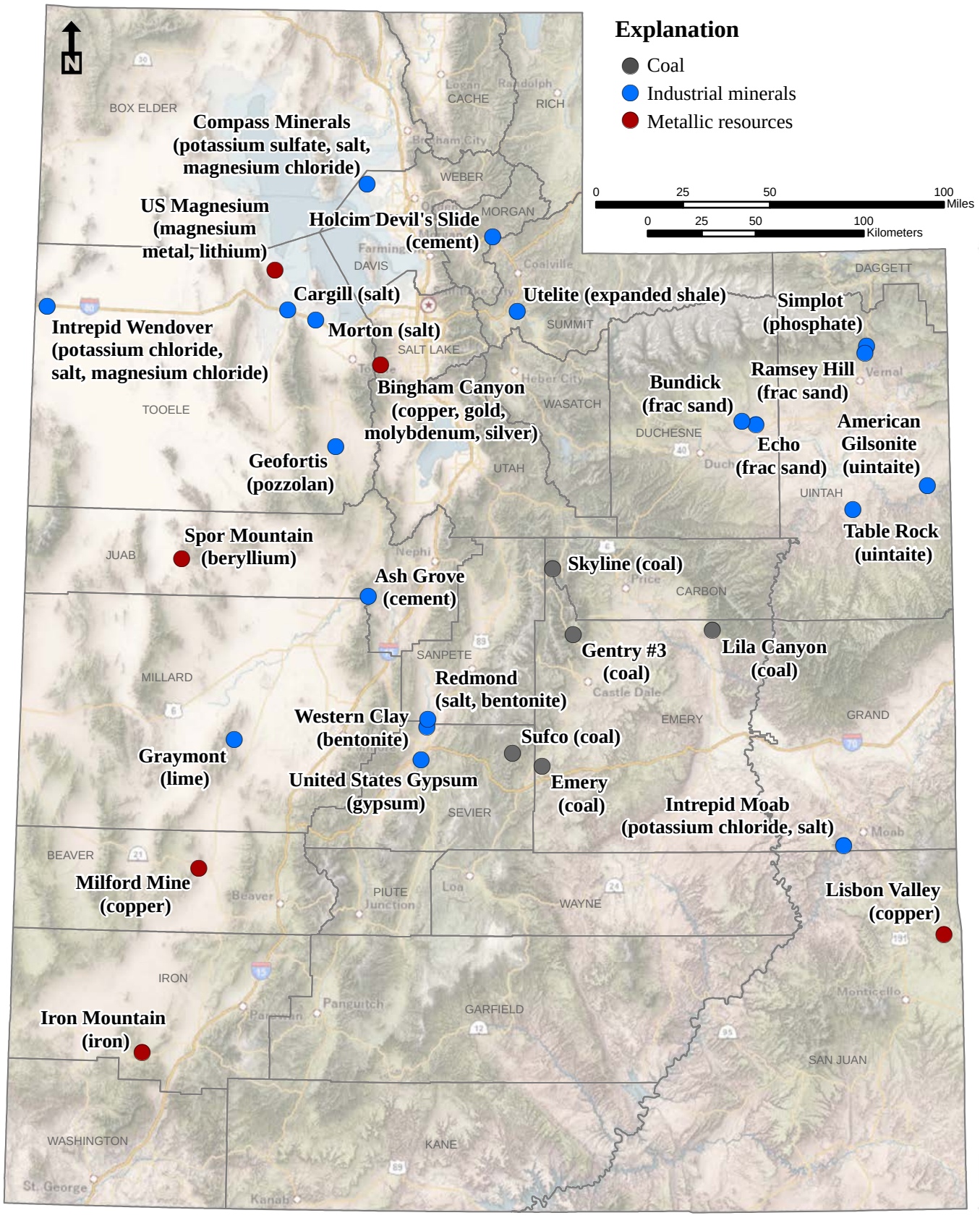


Figure 2. *Select metal, industrial mineral, and coal production locations active in 2024 in Utah. Basemap provided by Utah Geospatial Resource Center (UGRC).*

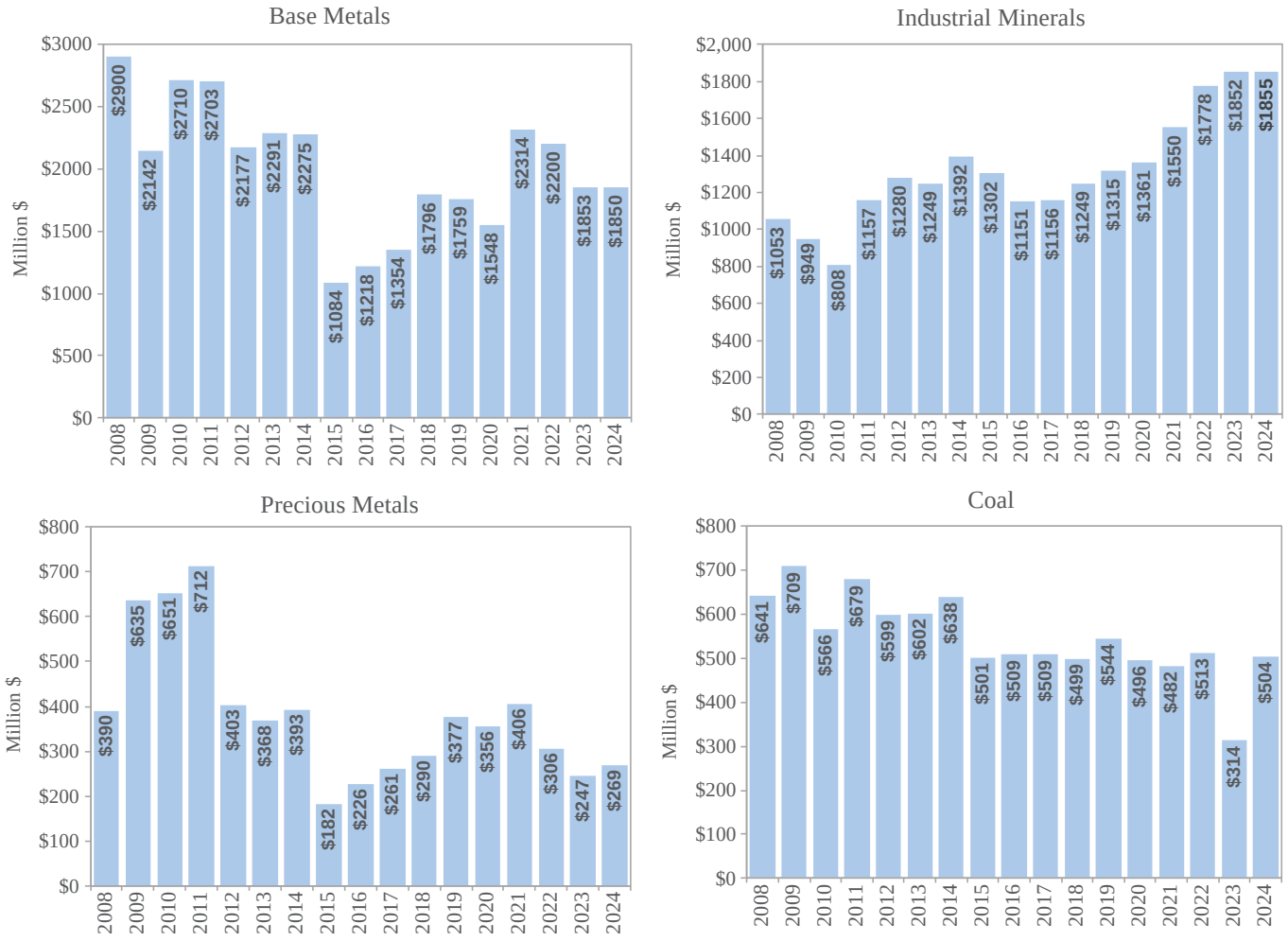


Figure 3. *Annual value of Utah mineral production in nominal dollars, 2008–2024. Data source: Utah Geological Survey.*

Utah is the only state to produce beryllium concentrate, potassium sulfate, and uintaite (Gilsonite®). Of these commodities, beryllium was included in the U.S. Geological Survey's (USGS) 2022 list of critical minerals (U.S. Geological Survey, 2022). Since 2020, Utah was one of only two domestic lithium producers, but production ceased in late 2024 and resumption of production from that operation is uncertain. Throughout this report, production is designated in US short tons (t) or million short tons (Mt) unless otherwise indicated.

In 2024, the USGS ranked Utah as 11th nationally for production of nonfuel minerals, which include metals and industrial minerals, the same ranking as 2023 (Table 1). The USGS estimate for Utah's 2024 nonfuel mineral production value remained consistent from 2023 at $3.1 billion (compared to the Utah Geological Survey [UGS] estimate of $4.0 billion), which accounted for 3.0% of the U.S. total, with cement, copper, gold, potash, and salt listed as principal commodities (U.S. Geological Survey, 2025a). Prior to 2023, Utah had ranked among the top 10 states for nonfuel mineral production for the past decade. In addition, Utah was the 13th largest coal producer of 21 coal-producing states in 2024 and accounted for 1.4% of total U.S. coal production (U.S. Energy Information Administration [EIA], 2025a).

The minerals regulatory program within the Utah Division of Oil, Gas and Mining (OGM) approved two large mine permits, fifteen small mine permits, and nineteen exploration permits in 2024 (Table 1). The large mine permits were issued for stone operations (Kim Coburn, OGM, written communication, June 2025).

The Utah School and Institutional Trust Lands Administration (SITLA), which manages Utah's 7.8 million total acres of trust land, issued 45 new mineral leases in 2024, relatively consistent with 43 issued in 2023 (Table 1). These leases were issued for the following commodities: metalliferous minerals (27), sand and gravel (10), limestone (6), building stone (1), and clay (1) (Andy Bedingfield, SITLA, written communication, April 2025).

In 2024, approximately 2800 new unpatented mining claims (based on unique serial numbers located in 2024) were filed on federal lands in Utah. This is a substantial decrease from the revised total of approximately 10,300 claims filed in 2023. In order of decreasing claims, new claims in 2024 were filed in Emery, Beaver, Iron, Millard, and Tooele Counties. All of these counties recorded over 100 new claims. Emery County

Table 1. *Utah mining rankings and statistics.*

Utah mining ranking or statistic	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
USGS rank of U.S. nonfuel mineral production value (metals and industrial minerals)	7th	5th	8th	10th	8th	8th	7th	8th	7th	8th	11th	11th
Fraser Institute annual survey of mining companies (favorability of mining jurisdiction)	15th of 112	14th of 122	9th of 109	11th of 104	15th of 91	7th of 83	14th of 76	25th of 77	11th of 84	17th of 62	1st of 86	--*
U.S. EIA rank for coal production by state	14th	13th	14th	10th	11th	12th	11th	10th	10th	12th	14th	13th
New OGM approved large mine permits	4	2	2	0	0	1	4	2	1	1	6	2
New OGM approved small mine permits	13	11	12	7	11	13	11	4	12	4	8	15
New OGM approved exploration permits	9	14	17	11	9	6	8	9	18	10	14	19
SITLA mineral leases issued	62	56	32	53	57	36	41	38	68	74	43	45
New BLM mining claims filed	2360	3110	975	5370	5710	5360	2280	3590	5060	8700	10,400	2800

Note: USGS = U.S. Geological Survey, EIA = U.S. Energy Information Administration, OGM = Utah Division of Oil, Gas and Mining, SITLA = Utah School and Institutional Trust Lands Administration, BLM = U.S. Bureau of Land Management
*Fraser Institute 2024 ranking not available at time of publication.

was the most active for new claims, likely due to renewed uranium interest in southeast Utah. Beaver County was the next most active, likely related to base and precious metals projects. Approximately 2680 claims in 2024 were lode claims, and 120 were placer claims. Lode claims did not decrease as notably from 2023 (3450 lode claims), indicating most of the variation from 2023 to 2024 in claim numbers was related to placer claims (6850 placer claims in 2023 vs. 120 in 2024). The stark variation in placer claims is likely due to a lithium staking rush in 2023, as lithium brine is staked as a placer.

Contributions by the Utah mining industry to the state tax base during 2003 and 2024 were significant (Figure 4). The metal, industrial mineral (non-metal), sand and gravel, and coal mining industries paid about $75 million in property taxes in 2023, up 12% from 2022 (calendar year totals, data for 2024 not yet available). These industries also contributed $14 million in mining-related severance taxes in 2023 and $12 million in 2024 (state fiscal year). All extractive industries, including oil and gas, paid over $83 million in Federal Mineral Lease disbursements in the 2024 state fiscal year. About 1.4% of Utah's gross domestic product came from the mining industry in 2023, 1.7% if oil and gas are included.

Mining employment in Utah was up about 2% from 2023 to 2024 and had a wage increase of about 3% (Figure 5). Due to challenging market conditions, a number of Utah operations were idled or reduced during 2024 to early 2025 (not reflected in current data), resulting in multiple layoffs: 186 workers were laid off when US Mag shut down operations; 45 employees were laid off and 45 furloughed at the Lisbon Valley copper mine; and approximately 100 workers were laid off when Utah Iron suspended mining at the Iron Mountain mine. Trixie and Kiewit also reduced mining operations, and Bingham Canyon is reducing open-pit production due to slope instability challenges.

Critical Minerals

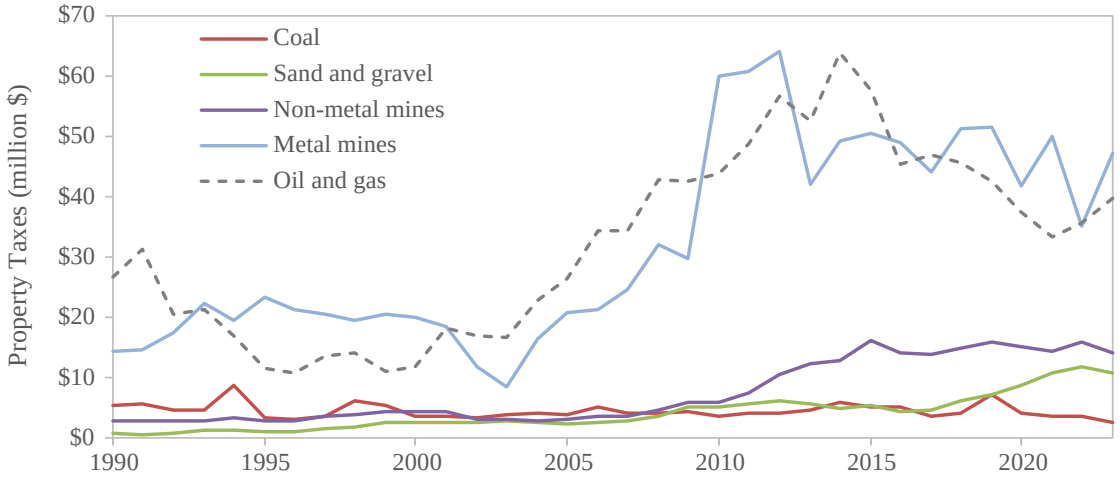
Critical minerals are defined as those necessary for economic or national security that have a supply chain vulnerable to disruption. In 2024, five critical minerals were produced in Utah (beryllium, lithium, platinum, palladium, and tellurium) and three more were either in recent production (lithium, magnesium metal) or are in near-term development (fluorspar). In addition to the produced and production-level critical minerals, Utah hosts known resources of six more (aluminum, indium, gallium, germanium, vanadium, and zinc) plus additional resources of lithium. The Energy Fuels mill[1] near Blanding, Utah, is one of the only domestic mineral processing facilities able to produce intermediate rare earth products, such as neodymium praseodymium oxalate and heavy rare earth concentrate, from monazite ore sourced outside of Utah.

More details on the produced and production-level Utah critical mineral operations are given below, and further information on the known resources can be found in Mills and Rupke (2023) and Rupke and Boden (2023).

- Beryllium: Utah is the only domestic producer of beryllium, sourced from the Spor Mountain mining district in Juab County. Based on estimated global production, Spor Mountain alone accounted for over 55% of global beryllium production (2024 MCS). The amount of ore remaining at Spor Mountain can support mining for at least 75 years, and currently more ore is produced annually than is used in the domestic market.

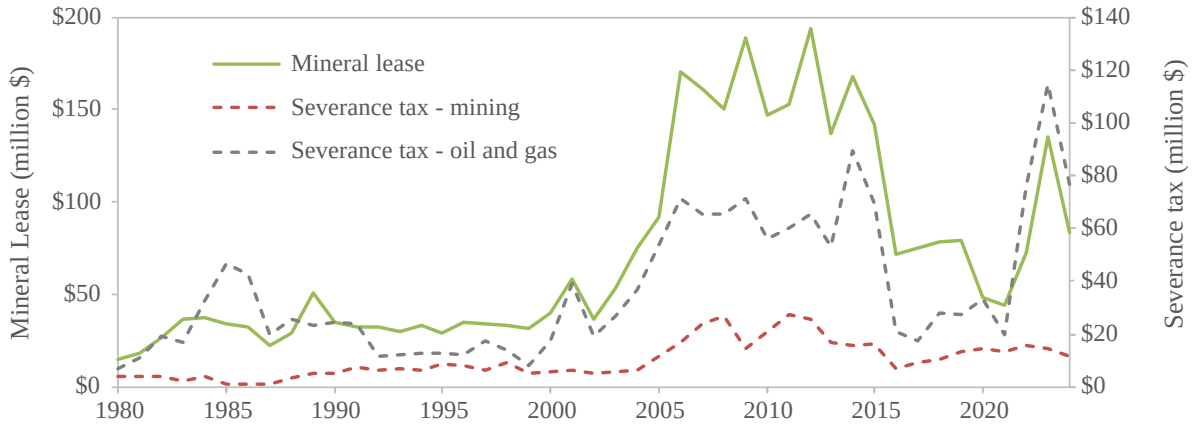
[1] Previously referred to as the White Mesa mill.

A.



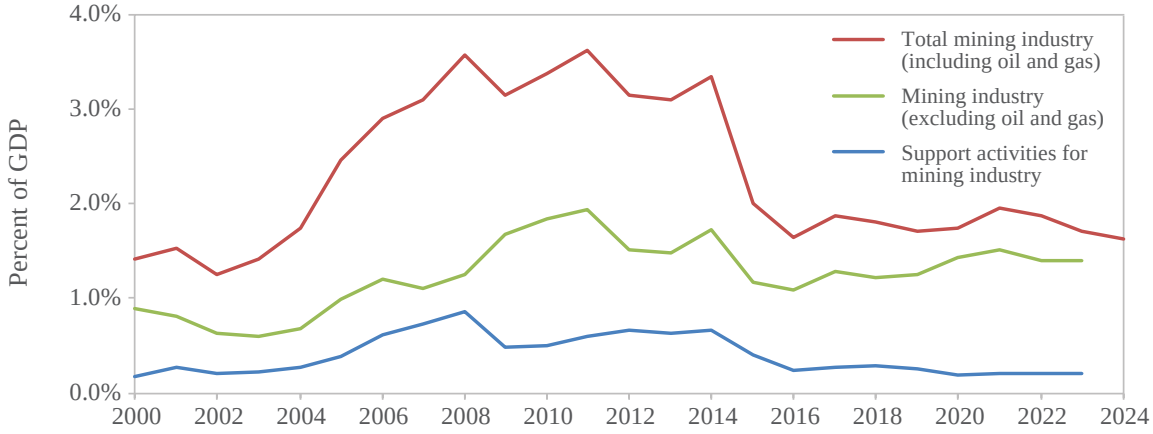
Source: Utah State Tax Commission
Note: Calendar year, presented in nominal dollars, 2024 data not yet available

B.



Source: Utah State Tax Commission
Note: State fiscal year, presented in nominal dollars

C.



Source: U.S. Bureau of Economic Analysis
Note: Calendar year, 2024 data for the Mining Industry and Support Activities not yet available

Figure 4. *Utah mining economic indicators.* ***A)*** *Property taxes charged against the mining industry, 1990–2023.* ***B)*** *Mineral lease revenue and severance taxes, 1980–2024.* ***C)*** *Percentage of Utah's gross domestic product (GDP) from mining-related activities, 2000–2024.*

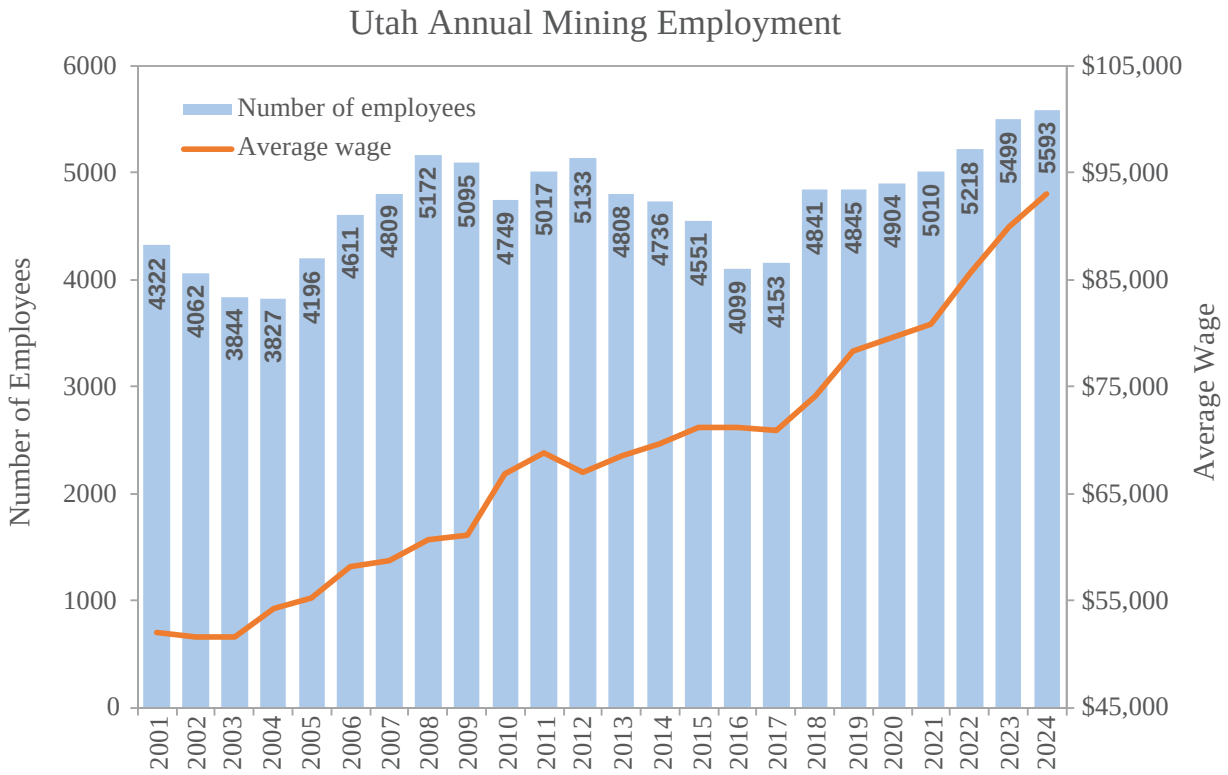


Figure 5. *Average annual mining employment and salaries (in nominal dollars) in Utah. Includes metal, industrial mineral, and coal mines and facilities; excludes oil and gas. Source: Utah Department of Workforce Services.*

- Lithium: Utah has multiple established resources of lithium but the only production has been as a byproduct of magnesium metal production from Great Salt Lake brines by US Magnesium. Lithium has been produced in Utah since 2020, but US Magnesium idled their operation in late 2024. Future production from the facility is uncertain.

- Tellurium: Bingham Canyon, operated by Kennecott Utah Copper Company (a subsidiary of Rio Tinto), produces tellurium as a byproduct of the copper refining process. A new tellurium recovery plant was built in 2021 and initial production began in May 2022. Annual capacity is designed to produce 22 t of tellurium, roughly 3% of global demand. The tellurium produced at Bingham Canyon is shipped to Canada, where it is used in the production of solar panels.

- Rare earths: Imported monazite sands are processed at the Energy Fuels mill to produce intermediate rare earth products. In 2024, the mill developed a new processing circuit and produced nearly 84,000 lbs of neodymium praseodymium (NdPr) oxalate and nearly 20,000 lbs of a heavy rare earth concentrate (mixed rare earth carbonate that contains only the heavy rare earth elements, including samarium, dysprosium, and terbium).

- Platinum and palladium: Bingham Canyon also produces modest amounts of platinum and palladium as a byproduct of the precious metal refining process. The platinum and palladium are hosted in a crude selenium product and are not refined to pure elemental form.

- Magnesium (metal): Utah has, in recent years, been the only domestic producer of magnesium metal, which is produced from Great Salt Lake brines via solar evaporation and electrolytic processing by US Magnesium. Since 2022, US Magnesium has not produced magnesium metal and the operation was idled in late 2024. Future production is uncertain.

- Fluorspar: Fluorspar (also known as fluorite) has historically been produced from the Lost Sheep mine in Juab County. The mine has been idle since the mid-2000s, but in 2020 Ares Strategic Mining began modern exploration to delineate the fluorspar resource and is currently developing a mine plan. Production is expected to begin in the near future. Once online, the Lost Sheep mine will be the primary producer of fluorspar in the U.S.

BASE AND PRECIOUS METALS

Production

Production Value Summary

Utah's total metalliferous resource production was $2.1 billion in 2024, of which $1.9 billion came from base metals and $270 million came from precious metals (Figure 6). The 2024 metalliferous resource production value is relatively stable from a

revised 2023 production value of $2.0 billion. The Bingham Canyon operation remains the state's most valuable metalliferous resource, accounting for $1.6 billion production value alone. Individual commodity updates are given below in order of decreasing mineral production value.

- Copper: Copper was mined at the Bingham Canyon and Lisbon Valley mines in 2024. Production at Bingham decreased from 2023 to 2024 due to slope instability issues (detailed below). These issues are expected to persist into 2026, reducing produced copper from the open pit, though the reduction in open-pit production will be partially offset as underground mining ramps up. Lisbon Valley is pursuing a mine expansion to the Lone Wolf deposit, with hopes to begin stripping the area in 2026. The price of copper increased modestly in 2024 and is expected to remain strong given the continued global push towards electrification in infrastructure and consumer goods.

- Gold and silver: Gold and silver were produced only by Bingham Canyon in 2024. Both the Kiewit and Trixie mines did not produce gold or silver in 2024. Like copper, production of both precious metals was less in 2024 than in 2023 due to the production challenges at Bingham Canyon, the largest precious metal producer in the state. The price of both gold and silver increased in 2024, and gold hit an all time high of $3100/oz in early 2025. Continued geopolitical and economic uncertainty are thought to be driving investment in precious metals.

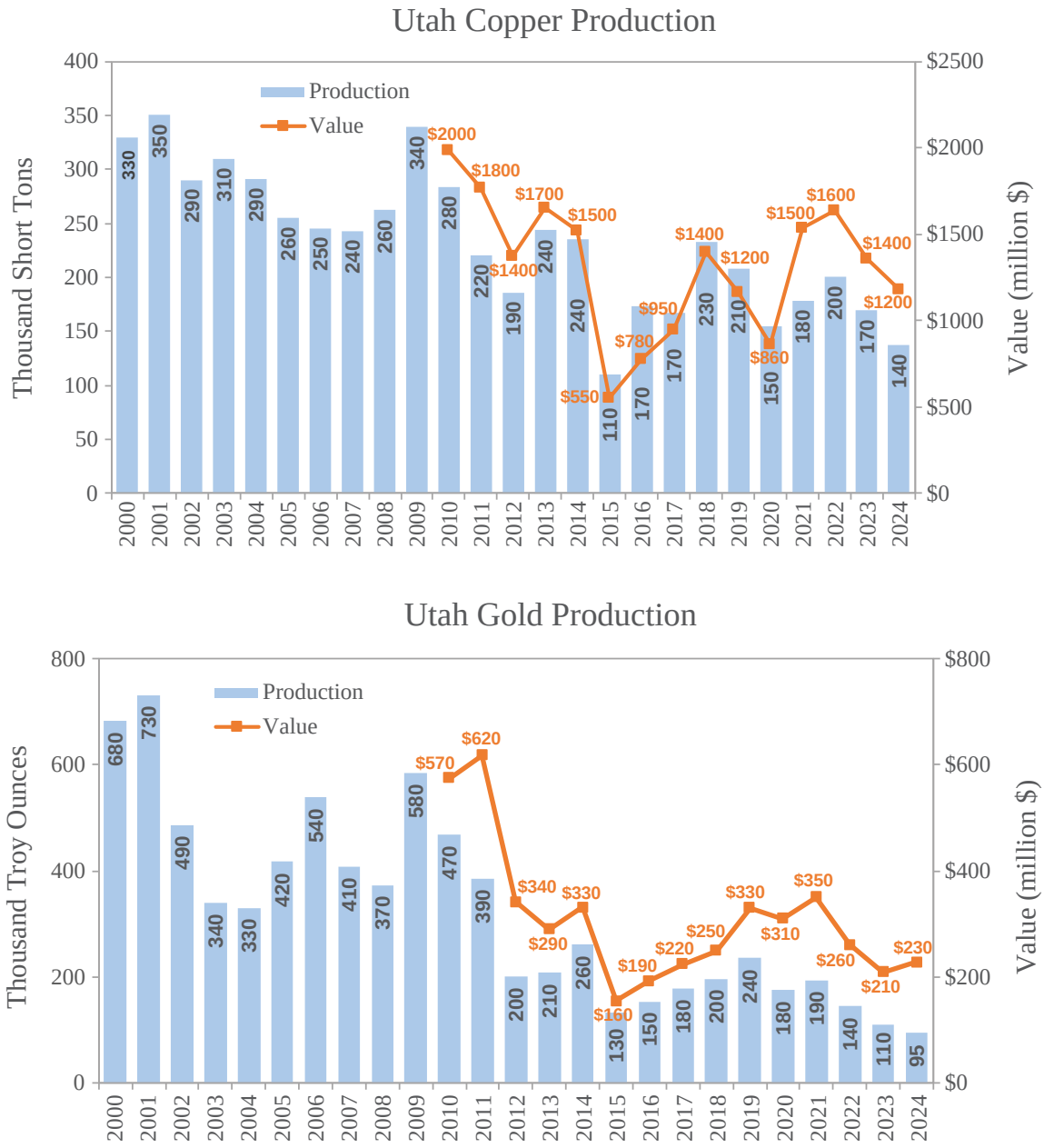


Figure 6. *Production (since 2000) and value (since 2010) of select metals. Value in nominal dollars.*

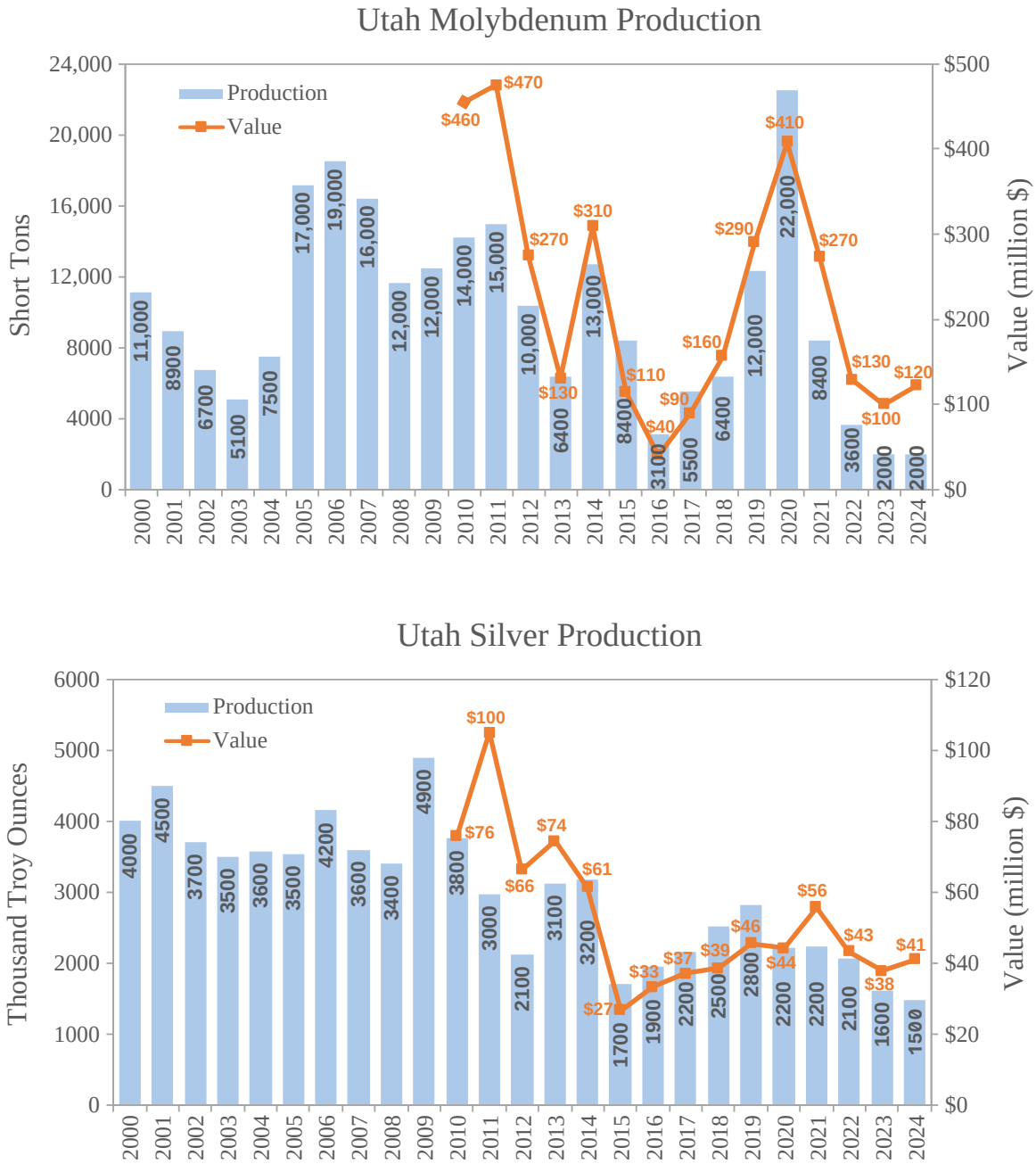


Figure 6 Continued. *Production (since 2000) and value (since 2010) of select metals. Value in nominal dollars.*

- Iron ore: Iron (magnetite) ore was mined at the Iron Mountain mine in Iron County during 2024 at a notable increase from 2023 production rates. However, in early 2025 the mine was placed on standby due to challenging economics in the global market.

- Molybdenum: Bingham Canyon mine is the only producer of molybdenum in Utah. In 2024 molybdenum production increased moderately, though the price in 2024 was slightly lower in 2023 so production value gains were muted.

- Beryllium: Beryllium ore is mined at the Spor Mountain mining district, the largest global producer of beryllium. Production increased from 2023 to 2024, and coupled with an increase in the price, the overall production value of beryllium increased by one-third. The increase in price is likely due to beryllium's use in aerospace and defense products, as well as its potential in new energy technologies.

- Magnesium (metal): US Magnesium's magnesium metal circuit has been down since 2022 and in 2024 they idled their entire operation. Future production is uncertain. In the past, magnesium metal was produced by electrolytic conversion of magnesium chloride concentrate that is produced from Great Salt Lake brines through evaporation.

Mining Operation Updates

- Bingham Canyon: The Bingham Canyon mine is an open-pit copper mine located in the Oquirrh Mountains, west of Salt Lake City, operated by Rio Tinto. Ore from the pit is processed on site through a series of smelter and refining processes. As a porphyry copper deposit, Bingham Canyon produces copper as a main commodity and also produces significant molybdenum, gold, and silver. Minor byproducts include platinum, palladium, and tellurium. In 2023, Bingham Canyon accounted for approximately 75% of Utah's total metalliferous mineral production value. During 2024, Bingham Canyon faced challenges due to increasing geotechnical risk on some of the pit walls. The zone of instability, in the area of the pit known as Revere, was known and managed for the past three years. However, snowmelt in spring of 2024 accelerated instability along two major faults. As a result of the instability, access to higher grade ore on the south wall of the pit has been limited, resulting in lower copper production and requiring a revised mine plan. Copper production is expected to be impacted through 2026. Due to the additional geotechnical work needed to mitigate the instability, an additional $300 million was allocated to the south wall pushback, which was originally a $1.8 billion project that began in 2020 and will continue through 2027. An additional $100 million was also allocated for geotechnical controls on the North Rim Skarn area, a $600 million project to begin underground mining that began in 2023. The North Rim Skarn is expected to begin production in 2025 and will help offset lower production from the pit, as will existing production from the underground mining at the Lower Commercial Skarn. Rio Tinto made steps to reduce carbon emissions at Bingham Canyon in 2024, including a transition to renewable diesel and investment in a 25MW solar plant. Construction on the solar plant started in late 2024.

- Milford: In 2024, the Milford Mining Company restarted copper mining in the Rocky mining district northwest of Milford, Utah. Ore is mined from a series of small open pits accessing high grade skarn mineralization. The ore, which is dominantly oxide, is processed through a flotation plant on site. The oxide material is then further processed at a solvent extraction electrowinning (SX-EW) plant onsite, producing high purity copper cathode. The minor sulfide ore is concentrated in the flotation process and then trucked to the Kennecott smelter in Magna. The company has plans to expand mining operations to additional existing pits, as well as upscale district exploration for future development targets.

- Lisbon Valley: Lisbon Valley copper mine is located in San Juan County, Utah. As a sediment-hosted copper deposit, oxidized ore from open-pit mining can be heap leached. Copper cathode is produced onsite through the SX-EW process. Ore reserves and resources were updated in 2023, reflecting 106 Mt at 0.27% Cu proven and probable reserves as well as 77 Mt measured, indicated, and inferred resource at slightly lower grade. In total, the updated reserves and resources account for nearly 900 Mlbs contained copper. Lisbon Valley Mining Company (LVMC) is pursuing plans to expand operations to orebodies in Lower Lisbon Valley, and stripping is planned to start at the Lone Wolf deposit in 2026. The expansion in this area is expected to extend the mine life by over 20 years. LVMC also continues to pursue in situ recovery (ISR) mining to supplement open-pit mining. In February 2024, LVMC obtained a $25M loan through the USDA's Business & Industry Loan Program, which is to support rural communities. In November 2024, 45 workers at the mine were terminated and 45 workers were furloughed.

- Iron Mountain: The Iron Mountain mine in Iron County is an open-pit iron mine operated by Utah Iron. Magnetite ore is processed onsite using ball and semi-autogenous grinding (SAG) mills and a magnetic separator. In 2024, Utah Iron made upgrades to the mill and processing infrastructure, including: completing its Ultra Fine Recovery (UFR) addition to reduce the volume of fine waste and enhance iron recovery; installing Filter press 4; activating Ball mill 2; adding new magnetic separators; and expanding housing for all of the mill upgrades from 2023 and 2024. In April 2025, Utah Iron announced it was suspending mining activities due to market uncertainties.

- Spor Mountain: The Spor Mountain mine is a series of open pits mining beryllium ore from the Spor Mountain Tuff. Ore is blended and stockpiled onsite then trucked to Delta, Utah, where it is processed to an intermediate beryllium hydroxide product. Mining continued throughout 2024 with no major interruptions. The ore reserves at Spor Mountain are estimated to be capable of supporting average production for a minimum of 75 years (Materion, 2024).

Exploration and Development

The following section provides details on some of Utah's larger exploration programs during 2024 (Table 2). The information presented here is not an exhaustive list of all exploration being conducted in Utah. The information represents significant exploration progress from companies who have made their projects public.

- Goldstrike/Antimony Ridge, Washington County (Goldstrike district): In 2024, Liberty Gold identified antimony mineralization at surface on the eastern side of the Goldstrike project hosted in jasperoid breccia. Follow up surface mapping and sampling, including 112 samples, yielded antimony values of up to 5.7% and 3.94 g/t Au

Table 2. *Select exploration and development projects in Utah, 2024.*

Project	County	Company[1]	Mining District[2]	Commodity	2024 Activity
New Years*	Beaver	Hawk Resources Ltd. (Alderan Resources Ltd.)	San Francisco	Cu	Two soil sampling surveys totaling 714 samples and 3 diamond drill holes for a total of 950 ft, yielding 100 ft at 0.8% Cu (including intervals up to 1.7% Cu) and 85 ft at 1.3% Cu (including intervals up to 2.8% Cu).
Great Salt Lake**	Box Elder	Waterleaf Resources	n/a	Li	Conducted a pilot test of DLE technology on north arm brine from Great Salt Lake in first half of 2025.
Energy Sands	Emery	Pegasus Resources Inc.	San Rafael River	U-V	Expanded project area and conducted surface mapping and sampling; of 41 surface samples, 13 yielded >1% U3O8 and individual samples yielded up to 18.8% U3O8.
Bullfrog	Garfield	Energy Fuels Inc.	Henry Mountains	U	Engineering study evaluated surface/underground infrastructure needed to commence mining; additional evaluation work planned for 2025.
Tony M***	Garfield	IsoEnergy Ltd.	South Henry Mountains	U	Reopened the main decline mid-year and progressed with mine condition assessment and surface/underground mapping.
Velvet-Wood mine; Shootaring Mill***	Garfield	Anfield Energy Inc.	South Henry Mountains	U	Velvet-Wood Plan of Operations and Shootaring mill restart application submitted with intention to recommence mining and milling in 2026.
Green River Lithium**	Grand	Anson Resources Ltd.	n/a	Li	Initiated mineral resource drilling and received final water extraction approval. Produced first lithium carbonate from test unit in early 2025. Reported in-place indicated and inferred resource of 113,000 t LCE from subsurface brines.
Paradox Lithium**	Grand	Anson Resources Ltd.	n/a	Li	In-place indicated and inferred resource estimate of 1.7 Mt of LCE in subsurface brines within Pennsylvanian- and Mississippian-age units.
Yellow Cat	Grand	Anson Resources Ltd.	Thompson	U, V	Received drill permit for 24 shallow holes totaling ~3300 ft, planned for 2025.
Modena Draw**	Iron	Progressive Contracting, Inc.	n/a	Pozzolan	Permitted a small mine with OGM to extract pozzolanic material from volcanic deposits in Modena Draw.
Beryllium Butte	Juab	Rockland Resources Ltd.	Honeycomb Hills	Be, Ga, Rb	Developed drill plan for Saddle target, reported 54 samples with >30 ppm Ga and an average of 729 ppm Rb across the 122 sample set, with a high of 1420 ppm.
Lost Sheep mine**	Juab	Ares Strategic Mining	Spor Mountain	F (fluorspar)	Plans to begin production in the near future; continuing construction of processing facilities; conducted mine development and drilling in 2024
Main Tintic*	Juab	Ivanhoe Electric (High Power Exploration Inc.)	Main Tintic	Polymetallic	Five diamond drill holes totaling ~21,300 ft targeting deep porphyry targets in the Mammoth area. Drilling intersected narrow Au-Ag-bearing carbonate-replacement mineralization.
Trixie and East Tintic*	Juab/Utah	Osisko Development Corp.	East Tintic	Au-Cu	New measured, indicated, and inferred resource >200,000 oz Au for Trixie; underground chip samping on 4 develpment faces yielding 1.07 g/t Au and 25.45 g/t Ag over 20 ft (including 90.20 g/t Au and 226.33 g/t Ag over over 1 ft); 2 diamond drill holes totaling 9580 ft in the Big Hill porphry target, two additional holes in the Big Hill West and Zuma porphyry targts (results pending).
Kings Canyon	Millard	Infield Minerals Corp.	Kings Canyon	Au	Project acquired, initial surface sampling of 7 samples with results up to 1.28 g/t Au.
Thompson Knolls	Millard	BCM Resources Corp./Inland Explorations Ltd.	Kings Canyon	Cu	Partnered with researchers from Colorado School of Mines to develop mineralization vectors based on skarn intercepted in previous drilling to refine future porphyry drill targets.
Deer Trail*	Piute	DT Mining LLC (MAG Silver Corp.)	Mount Baldy-Ohio	Cu-Au	Four diamond drill holes totaling ~19,200 ft, results included 1) expansion of the Carissa zone (including 964 ft grading 7.0 g/t silver, 0.2% copper and 0.2% zinc), 2) definintion of a Nodular Gold zone (including 4.5g/t Au over 97 ft), and 3) high grade extension of the Deer Trail mine at depth (including 9 ft grading 151 g/t silver, 0.5 g/t gold, 3.7% lead and 2.5% zinc).
Utah Lithium Project**	San Juan	Mandrake Resources	n/a	Li	In 2024, released in-place inferred resource estimate of 3.6 Mt of LCE in subsurface brines for their project in the Lisbon Valley area.
Harts Point***	San Juan	Kraken Energy Corp./Atomic Minerals Corp.	n/a	U	Completed 7 drillholes, 3 of which intercepted elevated radioactivity based on gamma probe results. 2025 drilling has been permitted for 15 exploration holes targetting the Moss Back Member of the Chinle Formation.
Blue Jay	San Juan	Urano Energy Corp. (C2C Metals Corp.)	La Sal	U	Acquired project.
Central Lisbon Project	San Juan	Sassy Gold Corp.	Lisbon Valley	U	Acquired project.
Sahara	San Juan	Ashley Gold Corp./Western Uranium and Vanadium Corp.	Lisbon Valley	U	Acquired project and conducted regional surface assessment, include surface samples grading 1.2 U3O8 equivalent.
Mercur*	Tooele	Revival Gold Inc./Ensign Minerals Inc.	Mercur	Au	Project purchased by Revival Gold, Preliminary Economic Assessment in early 2025 detailing 95,600 oz Au per year for a mine life of 10 years.
Silicon Ridge**	Utah	Ionic Mineral Technologies	Lake Mountains	Halloysite (clay)	Evaluating a halloysite deposit in the southern Lake Mountains.
Goldstrike/Antimony Ridge*	Washington	Liberty Gold Corp.	Goldstrike	Au, Sb	Identified antimony mineralized zone at the Goldstrike project including surface sampling results up to 5.7% Sb and 3.94g/t Au.

[1]Parentheses indicate alternative or previous company names, forward slash indicates change of ownership or joint venture.
[2]As defined in Krahulec (2018).
*More detail on these projects provided in the Base and Precious Metals section text.
**More detail on these projects provided in the Industrial Minerals section text.
***More detail on these projects provided in the Uranium section text.

in the same sample. The mineralized zone is currently mapped as 1500 ft strike length and up to 30 ft thick. Liberty Gold has stated intentions to spin the Antimony Ridge project off into a separate company focused on critical minerals exploration.

- Mercur, Tooele County (Mercur district): The Mercur project was purchased by Revival Gold from Ensign Minerals in mid 2024 and in early 2025 released an updated Preliminary Economic Assessment. The PEA details production of 95,600 oz Au per year over a 10 year mine life. The updated indicated and inferred resource is 1,372,000 oz Au between South and Main Mercur areas. Further drilling and geophysics are recommended in the report to improve resource confidence and expand the known mineralization.

- New Years, Beaver County (San Francisco district): Hawk Resources (previously Alderan Resources) collected 294 soil samples over the New Years prospect which led to drilling three diamond drill core holes for a total of 950 ft. The first hole was lost prior to intersecting mineralization. The remaining two holes intersected mineralization (NY2024-DDH2 intersected 100 ft at 0.8% Cu, including intervals up to 1.7% Cu; NY2024-DDH3 intersected 85 ft at 1.3% Cu, including intervals up to 2.8% Cu). The company completed an additional 420 soil samples and a TEM survey over the Cactus deposit to refine future drill targets.

- Main Tintic, Juab County (Main Tintic district): Main Tintic is a carbonate replacement deposit (CRD) and porphyry-prospective district held by Ivanhoe Electric. In 2024, Ivanhoe reprocessed IP data and updated the exploration model to reflect additional conductive responses associated with Mammoth and Grand Central mines at depth. Drilling in 2024 included five diamond holes for a total of ~21,300 ft focused on deep porphyry targets around the Mammoth mine area. Drilling intersected narrow, precious metals-bearing carbonate-replacement-type mineralization, interpreted as the distal expressions of a porphyry system.

- Deer Trail project, Piute County (Mount Baldy–Ohio district): Deer Trail is a CRD and deep porphyry exploration project operated by MAG Silver via DT Mining LLC. DT completed four diamond drill holes in 2024, totaling nearly 19,200 ft. The drilling expanded the Carissa Cu-Ag skarn zone and, significantly, intersected 964 ft grading 7.0 g/t silver, 0.2% copper and 0.2% zinc. In addition to verification and expansion of the Carissa zone, drilling also defined a Nodular Gold Zone proximal to the Deer Trail mine (grading 4.5g/t Au over 97 ft) and intersected a high grade extension of the Deer Trail mine at depth (intercepts included 9 ft grading 151 g/t silver, 0.5 g/t gold, 3.7% lead and 2.5% zinc). Work in 2025 includes RC pre-collaring holes to mitigate difficult drilling conditions and building upon the porphyry vectoring model developed through the recent drilling.

- Trixie mine, Juab and Utah Counties (East Tintic district): Trixie mine is a high-grade epithermal deposit operated by Osisko Development. In 2024 a new mineral resource estimate was released for the Trixie deposit, including a total measure, indicated, and inferred resource of 201,000 oz Au. Four underground chip samples were taken on new development faces and results included 1.07 g/t Au and 25.45 g/t Ag over 20 ft (including 90.20 g/t Au and 226.33 g/t Ag over over 1 ft). Two exploration diamond drill holes were drilled on the Big Hill porphyry target mid year totaling 9580 ft and intersected porphyry intrusions and intrusive breccias, but only minor anomalous copper and molybdenum were intersected. Two additional exploration holes were initiated in December 2024 on the Big Hill West and Zuma porphyry targets, results pending. In early 2024, Osisko noted an impairment between $80 to $120 million on the Trixie mine.

INDUSTRIAL MINERALS

Production

Industrial mineral production in Utah during 2024 had an estimated value of $1.9 billion, which was 2.8% lower than the revised 2023 value (Figure 3). The largest contributor was the construction aggregate (sand and gravel, crushed stone) and dimension stone group. These products had a combined value of $650 million (a 1.6% increase from 2023) and accounted for 35% of Utah's total industrial mineral production value in 2024. The second largest contributor was the potash, salt, and magnesium chloride group, which are all brine- and evaporite-derived commodities. These products had a combined value of $510 million in 2024 (an 8.3% decrease from 2023) and accounted for 28% of the industrial mineral total. The third-largest contribution to the value of industrial minerals production came from the Portland cement, pozzolan, lime, and limestone product group. These products had a combined value of nearly $340 million in 2024, a 3.5% increase from 2023, and accounted for 18% of the total industrial mineral value. Together, these three commodity groups contributed 81% of the total 2024 value of industrial minerals produced in Utah. The remaining value came from phosphate, uintaite, clay and shale, silica and industrial sand, lithium, and gypsum.

Sand and Gravel, Crushed Stone, and Dimension Stone

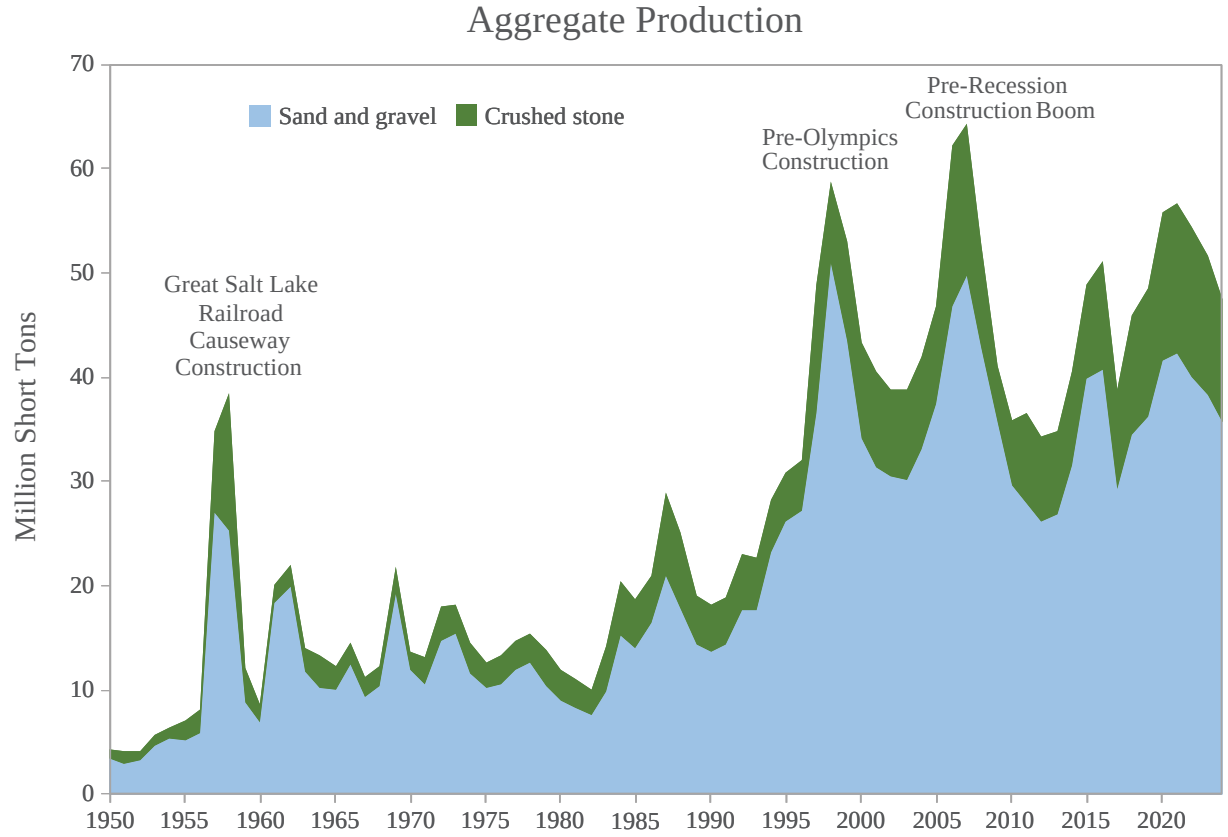
Sand and gravel, crushed stone, and dimension stone are produced by many private and government entities. Given the numerous producers of this commodity group, the UGS does not survey all the operators and relies on USGS data for statewide production estimates. During 2024, approximately 36 Mt of sand and gravel was produced in Utah (6.6% less

than the revised 2023 production estimate) worth $520 million (U.S. Geological Survey, 2025b) (Figure 7). About 12 Mt of crushed stone worth $130 million (U.S. Geological Survey, 2025b) represented a 12% production decrease from revised 2023 estimates (Figure 7). Several thousand tons of dimension stone were also produced. Sand and gravel and crushed stone are construction aggregates used in applications such as concrete aggregate, asphalt aggregate, and road base. During 2024, at the direction of the Utah legislature, Stantec conducted a study of Utah's construction aggregate market, regulatory environment, and resources (Stantec, 2024). The report was overseen by OGM and is available on the Utah State Legislature website.

Potash, Salt, and Magnesium Chloride

The brine- and evaporite-derived commodities produced in Utah include potash, salt (NaCl), and magnesium chloride. Potash is produced as potassium sulfate (sulfate of potash or SOP) and potassium chloride (muriate of potash or MOP). Potash production in Utah totaled 390,000 t and was valued at approximately $210 million in 2024 (Figure 8). Compass Minerals produces potassium sulfate from Great Salt Lake brine, Intrepid Potash-Wendover produces potassium chloride from shallow brines in the Great Salt Lake Desert, and Intrepid Potash-Moab produces potassium chloride from a solution mining operation targeting deep, subsurface evaporites of the Pennsylvanian-age Paradox Formation (Figure 2). Potassium sulfate generally has a higher (+$270 per ton in 2024) market value than potassium chloride, but the primary use of both types of potash is fertilizer. Potash prices rose dramatically during 2022 and decreased during 2023 and 2024, but still remained slightly higher than 2021 prices. The 2022 price increase was due to the war in Ukraine, as Russia and Belarus are among the top global potash producers.

About 3.6 Mt of salt was produced in Utah in 2024, with an estimated production value of $260 million (Figure 8). Salt production was about 14% lower than 2023. About 79% of the salt was produced from Great Salt Lake brine by four operators: Compass Minerals, Cargill Salt, US Magnesium, and Morton International (Figure 2), in descending production order. The remainder was from Redmond Minerals, Intrepid Potash-Moab, Intrepid Potash-Wendover, and Willow Creek Salt (in descending production order). Redmond Minerals operates an underground mine near Redmond in Sanpete County (Figure 2) that produces salt from the Jurassic Arapien Shale. Willow Creek Salt operates a surface mine east of Redmond that also produces salt from the Arapien Shale. Salt produced in Utah is used for various purposes including road deicing, water treatment, agricultural supplements, and industrial applications. Redmond Minerals and Morton International also produce food-grade salt from their respective facilities at Redmond and Great Salt Lake.



Source: U.S. Geological Survey

Figure 7. *Utah aggregate production, 1950–2024.*

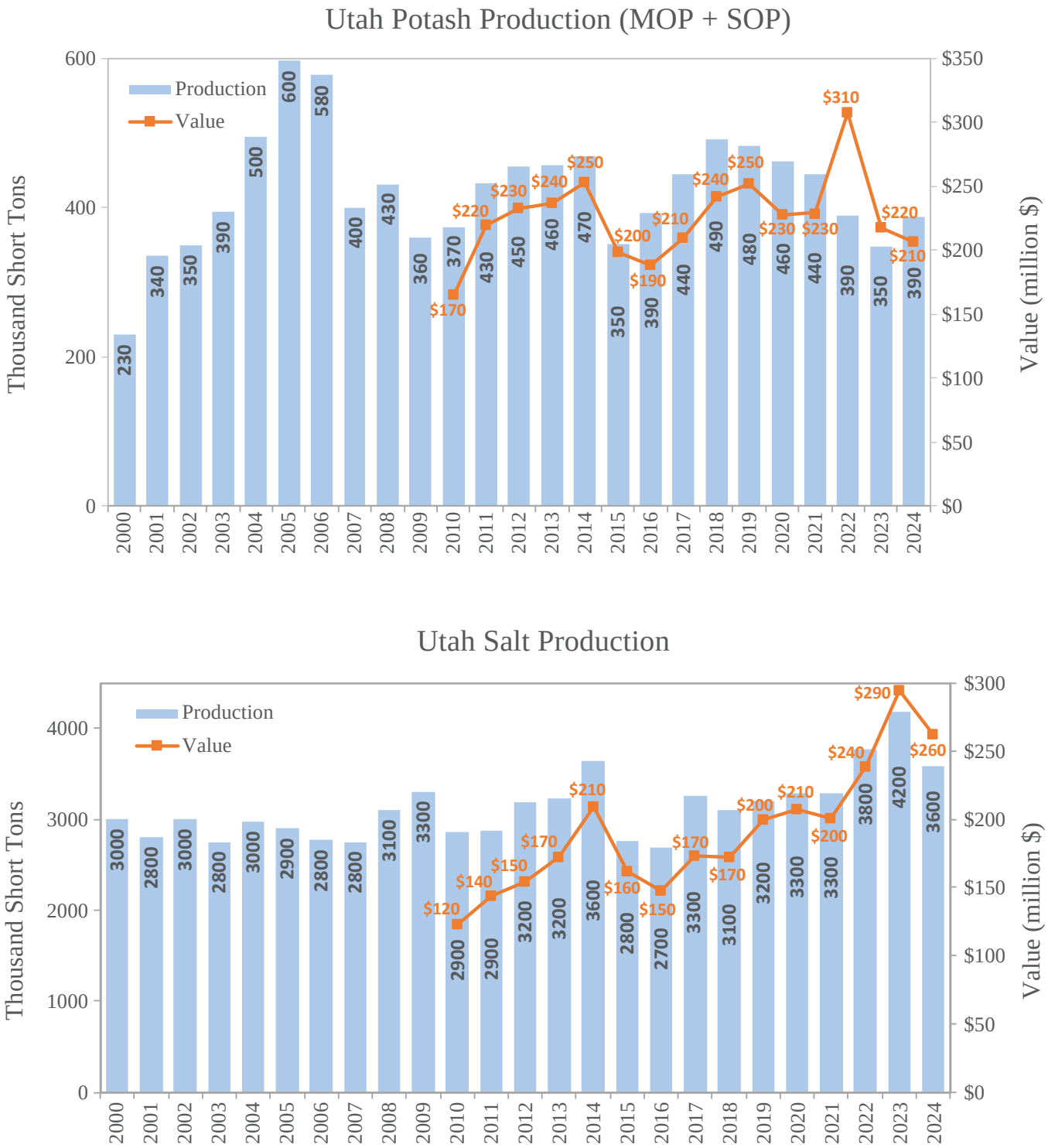


Figure 8. *Production (since 2000) and value (since 2010) of potash (all types) and salt. Values in nominal dollars. Data source: Utah Geological Survey.*

In 2023, magnesium chloride brine production in Utah had an estimated production value of about $46 million. The magnesium chloride brine was produced by Intrepid Potash-Wendover and Compass Minerals. Compass also produced small amounts of magnesium chloride flake. Magnesium chloride is commonly used as a premium road deicer and as a dust suppressant for unpaved roads.

The most significant source of brine-derived products in Utah is Great Salt Lake. An estimated 3.3 Mt of total material was produced from Great Salt Lake brine in 2024, including salt, potash, magnesium chloride, and lithium. Production in 2024 was lower than our 2023 estimate of 3.8 Mt. The estimated value of mineral and brine production (including salt, potash, magnesium chloride, and lithium carbonate) from Great Salt Lake in 2024 was about $390 million. A recent study by the UGS examined how some of the important resources (lithium, magnesium, and potassium) in Great Salt Lake's brine have changed over time (Rupke, 2025).

Portland Cement, Pozzolan, Lime, and Limestone

Together, Ash Grove Cement and Holcim produced about 1.6 Mt of portland cement in Utah during 2024, having an estimated value of $240 million. Ash Grove Cement operates the Leamington quarry and plant east of Leamington in Juab County, and Holcim operates the Devil's Slide quarry and plant east of Morgan in Morgan County (Figure 2). Portland cement production and value have been fairly stable for the past several years. Ash Grove and Holcim also produce smaller amounts of sandstone, clay, and shale as raw materials for portland cement production.

Pozzolanic materials are typically high in silica and alumina and have cementitious properties that are useful to partially replace and, in some cases, enhance portland cement. Other benefits of pozzolans, compared to conventional cement production, include reduced manufacturing cost and reduced greenhouse gas emissions. In 2024, Ash Grove Cement acquired Geofortis' pozzolan mine in Rush Valley at Faust, Tooele County. The pozzolan resource is a tephra (volcanic ash) in the Tertiary Salt Lake Formation, and production from the mine expanded by about 30% from 2023 to 2024.

During 2024, Graymont Western U.S. remained the sole producer of lime in Utah and their production was about 3.0% lower than 2023. Graymont produces high-calcium quicklime and dolomitic quicklime from their quarry and plant in the Cricket Mountains about 35 miles southwest of Delta in Millard County (Figure 2). Lime is used for flue gas desulfurization, steel production, and a variety of other construction, chemical, and industrial applications.

In Utah, limestone is produced for both crushed stone and specialty purposes. Limestone produced for crushed stone is used for common construction aggregate and is included in the sand and gravel, crushed stone, and dimension stone commodity group resource and value estimates. During 2024, a few million tons of limestone was produced for specialty purposes, while most of this production was used to manufacture cement and lime (discussed above). However, a few smaller operations, such as Diamond Mountain Resources in Uintah County, intermittently produce limestone for flue-gas desulfurization at coal-fired power plants or other uses such as "rock dust" for coal mines.

Phosphate

Simplot Phosphates continues to be the major phosphate producer in Utah and mines ore from the Meade Peak Member of the Permian Phosphoria Formation. Their phosphate operation is located 12 miles north of Vernal in Uintah County (Figure 2). In 2024, the mine produced nearly 3.2 Mt of ore. The ore yielded about 1.2 Mt of phosphate concentrate (about 30% P_2O_5) after processing. The concentrate is transported in slurry form through a 96-mile underground pipeline to the Simplot fertilizer plant near Rock Springs, Wyoming. More than 95% of the phosphate rock mined in the United States is used to manufacture phosphoric acids to make ammonium phosphate fertilizers and animal feed supplements (U.S. Geological Survey, 2025a).

Since 2020, phosphate has also been produced at the Diamond Creek mine near Diamond Fork in Utah County for use as organic fertilizer. In 2024, Keras Resources mined a few thousand tons of phosphate rock from a roughly 7-ft-thick zone of the Meade Peak Member of the Permian-age Phosphoria Formation.

Uintaite (Gilsonite®)

Uintaite (also spelled "Uintahite" and commonly referred to as Gilsonite, which is a trademarked name) is a shiny, black, solid hydrocarbon that occurs in a swarm of narrow, but laterally and vertically extensive, veins in the Uinta Basin. It has been mined since the late 1880s, mostly in Utah with some minor production in the Colorado part of the basin. The largest producer of uintaite is American Gilsonite Company, with mines and processing facilities in southeastern Uintah County (Figure 2). Table Rock Minerals, LLC, also produced uintaite at the TRM #1 mine in the Uinta Basin south of Ouray in Uintah County. Over the past several years, uintaite production from the Uinta Basin has ranged up to about 85,000 t per year, depending on market conditions (specific production and price data are proprietary). Utah is the only place in the world that contains large deposits of uintaite, which has been shipped worldwide for use in numerous and diverse products including asphalt paving mixes, coatings, inks, and paints (Boden and Tripp, 2012). More recently, the oil and gas industry has used uintaite as an additive in drilling fluids. Uintaite helps control fluid loss and seepage, increase wellbore stability, prevent loss of circulation, and stabilize shale formations.

Clay and Shale

A few hundred thousand tons of clay and shale were produced in Utah in 2024 including bentonite, common clay, high-alumina clay, and expanded shale. Clay is produced at various small and large mines, often on an intermittent basis. Consequently, year-over-year production and value estimates are subject to significant change. Some of the largest producers of clay and shale products are Utelite (expanded shale), Interstate Brick (common clay), Ash Grove Cement (high-alumina clay), and LafargeHolcim (high-alumina clay), Western Clay (bentonite), and Redmond Minerals (bentonite). Uses for bentonite include well drilling and foundry operations, various civil engineering applications, and as litter-box filler. Common clay is largely used to make bricks, whereas most high-alumina clay from Utah is used to make portland cement. Applied Minerals Inc. intermittently produces a small amount of specialty clay (halloysite) and iron oxide from the Dragon mine in the Tintic Mountains. They have been researching potential applications and markets for halloysite over the past several years, but filed for bankruptcy in late 2024.

Expanded shale in Utah is produced by Utelite at their quarry and plant near Wanship in Summit County (Figure 2). Expanded shale is a lightweight aggregate, sometimes called "bloated shale," mainly used by the construction industry. It is produced by rapidly heating high-purity shale, derived from the Cretaceous-age Frontier Formation, to about 2000°F causing it to expand and vitrify. The resulting aggregate is durable, inert, uniform in size, and lightweight, having a density about one-half that of conventional aggregates. The material is used in roofing tile, concrete block, structural concrete, and horticultural additives, as well as for highway construction and geotechnical fill.

Silica and Industrial Sand

Silica and industrial sand production in Utah increased from 2023 to 2024 and had an estimated 2024 value of about $110 million. On Stansbury Island, Bolinder Resources mines quartzite from the Devonian-Mississippian-age Stansbury Formation as a source of industrial silica used as a flux at the Kennecott smelter. Some of the quartzite is also used as construction aggregate. Frac sand is relatively pure quartz sand that is used for hydraulic fracturing stimulations in oil and gas wells and a few companies are locally supplying frac sand to the Uinta Basin. North of Vernal, Ramsey Hill Exploration produces frac sand from the Triassic-Jurassic-age Nugget Sandstone and unconsolidated Quaternary mixed alluvial and eolian deposits (Figure 2). More recently, two companies have begun producing frac sand from the Brennan Basin Member of the Eocene-age Duchesne River Formation. Wildcat Sand operates the Echo mine and XCL/SM Energy operates the Bundick mine, both of which are west of Roosevelt (Figure 2). At least one sandstone horizon within the Brennan Basin Member is sufficiently quartz rich and friable for relatively easy disaggregation. A 40/170 mesh product is produced from the Echo mine and 30/70 and 50/140 mesh products are produced from the Bundick mine.

Gypsum

Four operators produced at least 650,000 t of gypsum in 2024 in Utah. The estimated value of 2024 gypsum production is about $13 million. The four Utah gypsum producers were Progressive Contracting, Inc., Diamond K Gypsum, Sunroc Corp., and United States Gypsum Co. Utah gypsum is commonly used in raw or crude form by regional cement companies as an additive to retard the setting time of cement and by the agriculture industry as a soil conditioner. Lesser amounts of higher value calcined gypsum are used to make wallboard by United States Gypsum, which operates a wallboard plant near Sigurd in Sevier County (Figure 2). Most of the gypsum extracted in Utah is from the Jurassic-age Carmel Formation or the Arapien Shale.

Lithium

Utah entered its fourth year of lithium production in 2024. US Magnesium was producing lithium from byproduct material of magnesium metal production. Their target capacity for lithium production had been about 10,000 t of lithium carbonate per year and in mid 2024 US Magnesium announced that they had employed new DLE (direct lithium extraction) processing technology to increase production. The DLE technology was from International Battery Metals and intended to produce high-grade lithium chloride for producing battery-grade lithium. However, in late 2024 US Magnesium idled its operations. Future production of lithium is uncertain.

Exploration and Development

Exploration and development activities for industrial minerals in Utah have centered on lithium with additional activity related to a few other commodities (Table 2). This summary generally excludes the activities of smaller aggregate or construction material operations, which are difficult to track but are often a significant part of industrial mineral exploration and development. The information in this section is largely from company websites, press releases, OGM records, and personal communications. Several companies are pursuing lithium in Utah, primarily in brines, and hold land positions in a variety of places in Utah including the Paradox Basin and the Great Salt Lake Desert (e.g., the Bonneville Salt Flats, Pilot Valley). Because of the high magnesium content of Utah's brines, DLE technology would likely be needed to exploit lithium from Utah's brine deposits. Multiple DLE technologies are in development, but wide deployment of DLE technology has yet to be realized. For additional information on Utah lithium please see Mills and Rupke (2023) and Rupke and Boden (2023).

Notable exploration and development updates are below. The relevant commodity is noted at the beginning of each bullet point.

- (Lithium) Intrepid Potash-Wendover announced in late 2023 that they were evaluating possible lithium production from their facility near Wendover in the Great Salt Lake Desert. Their announcement reported that Intrepid's final byproduct brine, that has been through multiple evaporation stages, can reach concentrations of over 1500 ppm lithium.

- (Lithium) In mid-2021, Compass Minerals, a Great Salt Lake mineral producer, announced the identification of a lithium resource with intent to develop production. Compass reported an in-place indicated and inferred resource of 2.7 Mt of LCE within the interstitial brine of salts accumulated in their evaporation ponds and in the waters of Great Salt Lake (2.56 Mt) (Havasi, 2022). However in February 2024, Compass ended their lithium program citing increased regulatory risk around the project.

- (Lithium) Anson Resources has been pursuing lithium resources in subsurface brines in the Paradox Basin within two large land blocks near Moab (Paradox Lithium project) and Green River (Green River Lithium project) in Grand County. Anson has defined an Australian Joint Ore Reserves Committee (JORC)-compliant resource estimate that contains an in-place indicated and inferred 1.7 Mt of LCE in brine in the Pennsylvanian Paradox Formation and underlying Mississippian carbonates for their Paradox Lithium project (Anson Resources, 2023). For their Green River Lithium project, they drilled a well near Green River (Bosydaba#1 well) in early 2024 and reported elevated lithium grades (up to 138 mg/L Li) in the brine encountered in the Mississippian Leadville Limestone. In mid 2025 they released a JORC-compliant resource estimate for their Green River Lithium project based on their drilling which includes an indicated and inferred resource of 113,000 t of LCE from brines in the Leadville Limestone assuming an average lithium grade of 94 mg/L (Anson Resources, 2025).

- (Lithium) In 2023, Mandrake Resources re-entered five wells in the Lisbon Valley area of the Paradox Basin to test brine for lithium content as part of their Utah Lithium project. Similar to Anson, they are targeting the Pennsylvanian Paradox Formation and underlying units. In October 2024, Mandrake released a JORC-compliant in-place inferred resource of 3.6 Mt of LCE for their Utah Lithium project (Mandrake Resources, 2024). The resource includes lithium brines from the Paradox Formation, the Leadville Limestone, and the Devonian-age McCracken Sandstone. Average lithium grades in these horizons are estimated to range from 69 to 142 mg/L.

- (Lithium) Waterleaf Resources, a subsidiary of Lilac Solutions (a company that produces lithium extraction technology), conducted a pilot test of their DLE process at Great Salt Lake. The pilot facility is on the north arm of the lake north of Rozel Point/Spiral Jetty. Results from their pilot test are not yet available. If deemed successful, they have indicated an intent to apply for permits to construct a commercial-scale facility.

- (Fluorspar) Ares Strategic Mining has been working towards reopening the Lost Sheep fluorspar mine in the Spor Mountain district in Juab County. Historically, the Lost Sheep mine was the most productive fluorspar mine in Utah and has produced about 170,000 t of fluorspar from a series of mineralized breccia pipes. The mine has an active small mine permit from OGM. Since 2020, Ares has completed exploration drilling, geophysical surveys, and geologic mapping to delineate the fluorspar resources of their land holdings, which consist of nearly 6000 acres of claims across much of the Spor Mountain area. They have also developed processing capabilities located in Delta. In 2024, Ares commenced additional drilling in their primary mine area, expanded their fluorspar target, purchased equipment, and worked on mine development in anticipation of production. Fluorspar is considered a critical mineral and the United States is almost completely import reliant for the mineral. Consequently, if the Lost Sheep mine resumes production it would be the most significant fluorspar producer in the United States.

- (Potash) Crystal Peak Minerals was previously close to development of a potassium sulfate project at Sevier Lake/Playa. They had delineated a resource (Brebner et al., 2018) and received permits and approvals for development, but were unable to raise sufficient capital to advance the project. In mid 2025, Crystal Peak Minerals received approval from the BLM for the initial phase of their project. No announcements have been made regarding a potential timeline for development.

- (Pozzolan) In 2024, a small mine permit was granted by OGM to Progressive Contracting, Inc. to extract natural pozzolan in western Iron County. The proposed quarry is in Modena Draw and 13 lode claims (Modena-1 through -13) cover the project area. Few details on the project are available, but limited information suggests that the deposit is a volcanic tuff, likely rhyolitic.

- (Halloysite) Ionic Mineral Technologies has leased an area in the southern part of the Lake Mountains in Utah County where they are evaluating a halloysite deposit that they have named Silicon Ridge. The intent is for Silicon Ridge to complement their already drill-defined Halloysite Hills deposit in Juab County.

URANIUM

Production

Domestic uranium production in 2024 was the highest in six years. Persistently low uranium prices from 2015 to 2020

stagnated exploration and development projects. Prices have been increasing steadily in recent years due to increasing interest in nuclear energy to meet growing energy demands. The sustained high uranium prices have spurred new uranium exploration globally, a trend observed in Utah as well as at multiple projects that were revitalized or sold during 2024.

Energy Fuels is currently the only uranium producer in Utah. Underground mining recommenced at their Beaver (Beaver Shaft), La Sal (La Sal Decline), and Pandora operations in early 2024. Together, the three mines produced 29,780 tons of ore in 2024 valued at approximately $13 million. In 2025 Energy Fuels plans to rehabilitate more areas of the La Sal Complex and complete expansion of the Pandora development area.

The Energy Fuels mill, located outside Blanding, is the only conventional uranium mill in the United States. In addition to the conventional uranium circuit, the mill has a separate vanadium recovery circuit, and as of 2021 a new rare earth separation circuit was added. From 2021 to 2023 the mill produced a mixed rare earth carbonate product from monazite ore; from 2023 to 2024 a rare earth separation facility was installed to allow for the production of NdPr oxalate and a heavy rare earth concentrate. In 2024 the mill produced 158,000 lbs of uranium and 38,000 kg NdPr oxalate. Not all of the uranium produced is from Utah ore, as the company also processes alternate feeds from other sources. Energy Fuels plans to continue expansion of the rare earth processing infrastructure by completing a Phase 2 engineering study during 2025. Phase I is able to process 8000 to 10,000 t annually and produce NdPr oxalate and a heavy rare earth concentrate, whereas Phase II will increase throughput to 50,000 t and produce high-purity NdPr, Tb and Dy oxides. The processing for uranium and rare earths utilize the same early processing steps, so only one type of ore can be processed at a time. Although the monazite ore processed at the mill is not sourced from Utah, the Energy Fuels mill is an important part of the mining production and supply chain in Utah.

Exploration and Development

The following section provides details on some of Utah's significant uranium exploration programs during 2024 (Table 2). The information presented here is not an exhaustive list of all exploration being conducted in Utah; it represents significant exploration progress from companies who have made their projects public.

- Velvet-Wood mine: In May 2024, Anfield submitted a Plan of Operation to restart mining operations at the Velvet-Wood uranium and vanadium mine located in the Lisbon Valley mining district north of Monticello. In May 2025, the project was fast-tracked for review by the Trump administration and was approved in early June 2025. It is unclear when Anfield intends to begin mining and may rely on returning the Shootaring mill to operation (see below).
- Shootaring Canyon: Anfield submitted a production reactivation plan for the Shootaring Canyon mill, located near Tickaboo, Utah, to the State of Utah's Department of Environmental Quality (UDEQ). Anfield is targeting restart of mill production in 2027.
- Tony M, Garfield County (South Henry Mountains district): Tony M is a sandstone-hosted uranium deposit in the Salt Wash Member of the Morrison Formation. IsoEnergy acquired the Tony M project in 2023 and in 2024 successfully reopened the main decline. Work focused on rehabilitating the decline, sedimentological surface mapping, and underground mapping including a lidar survey. IsoEnergy intends to develop a mine plan and update the mine economics.
- Harts Point, San Juan County: Harts Point is a sediment-hosted uranium-vanadium project targeting mineralization in the Triassic-age Chinle Formation and is operated by Atomic Minerals Corp. and Kraken Energy. The Phase I drilling in 2024 included seven holes over a strike length of 1.5 km. Three holes intersected radioactivity, based on downhole gamma probe results. Phase II drilling has been permitted and 2025 plans include 15 deep (>1500 ft) exploration holes targeting the basal Moss Back Member of the Triassic Chinle Formation.

COAL

Production and Distribution

Three Utah coal operators produced 7.4 Mt of coal valued at $504 million from five underground mines in 2024 (Figures 9–11; Table 3). Production was just 7.0 million tons in 2023, the lowest since 1975, but increased 6.5% in 2024 due to production increases at Wolverine's Skyline and Sufco mines, as well as increases at the Bronco-owned Emery mine and minor production at Wolverine's new Fossil Rock mine. In contrast, the Gentry mine had lower production in 2024. Average annual employment at active or recently active mines stayed steady in 2024 at about 1350 (Figure 9), as most miners from the idled Lila Canyon and Coal Hollow were able to transition to other mines. Employment is expected to increase to about 1390 in 2025 as Wolverine continues to ramp up activities at the Fossil Rock mine. Coal mining productivity, the amount of coal produced in tons per employee hour, peaked in 2002 at 8.0 tons/employee hour, before dropping to an average of 4.4 tons/employee-hour between 2018 and 2022 (Figure 9). Productivity dropped to 2.5 tons/employee-hour in 2023 and increased slightly to 2.7 tons/employee-hour in 2024.

Demand at Utah coal-fired power plants was fairly stable from 2000 to 2015 at about 15.2 Mt a year, but dropped to an average of 11.6 Mt between 2016 and 2021, including a dip in 2020 to 10.5 Mt due to the COVID-19 pandemic (Figure 12).

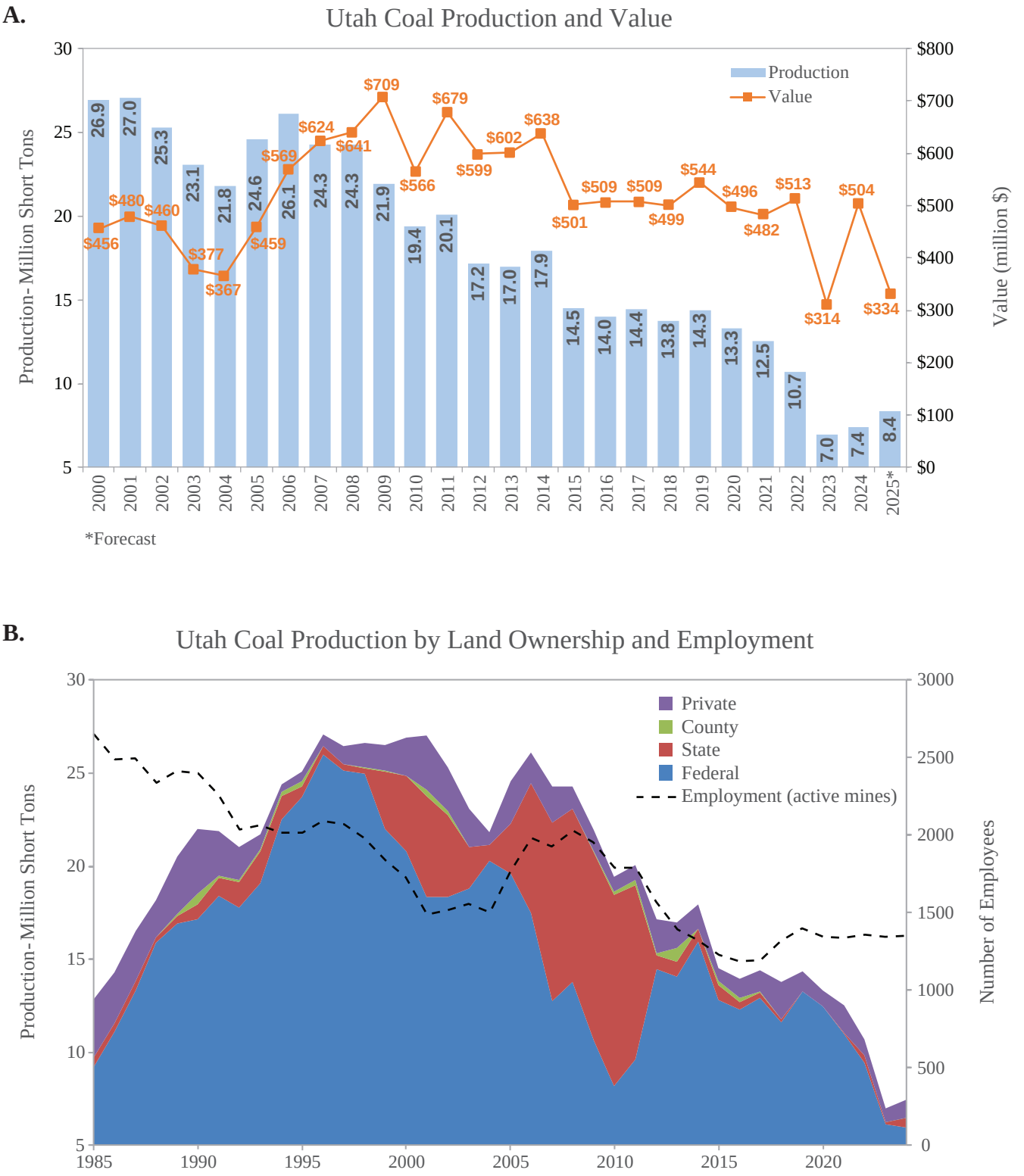


Figure 9. A) *Utah coal production and value in nominal dollars, 2000–2025. Data source: Utah Geological Survey and U.S. Energy Information Administration.* ***B)*** *Utah coal production by land ownership and employment at active mines, 1985–2024. Data source: Utah Geological Survey and Mine Safety and Health Administration.*

C.

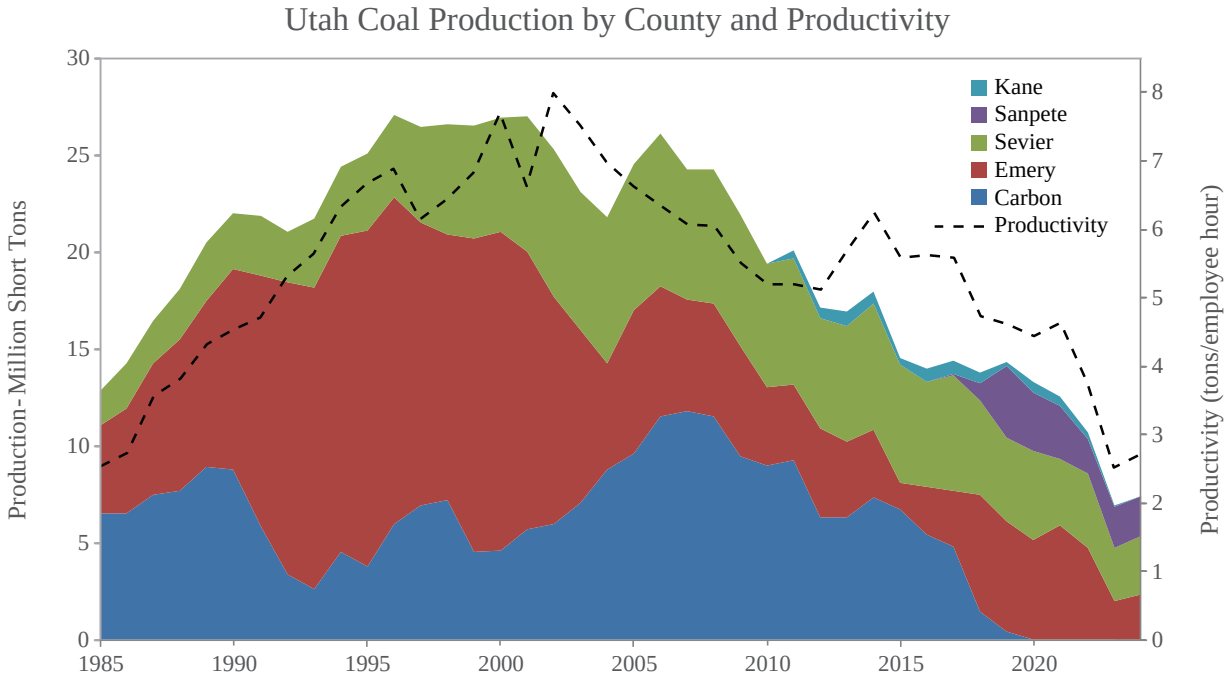
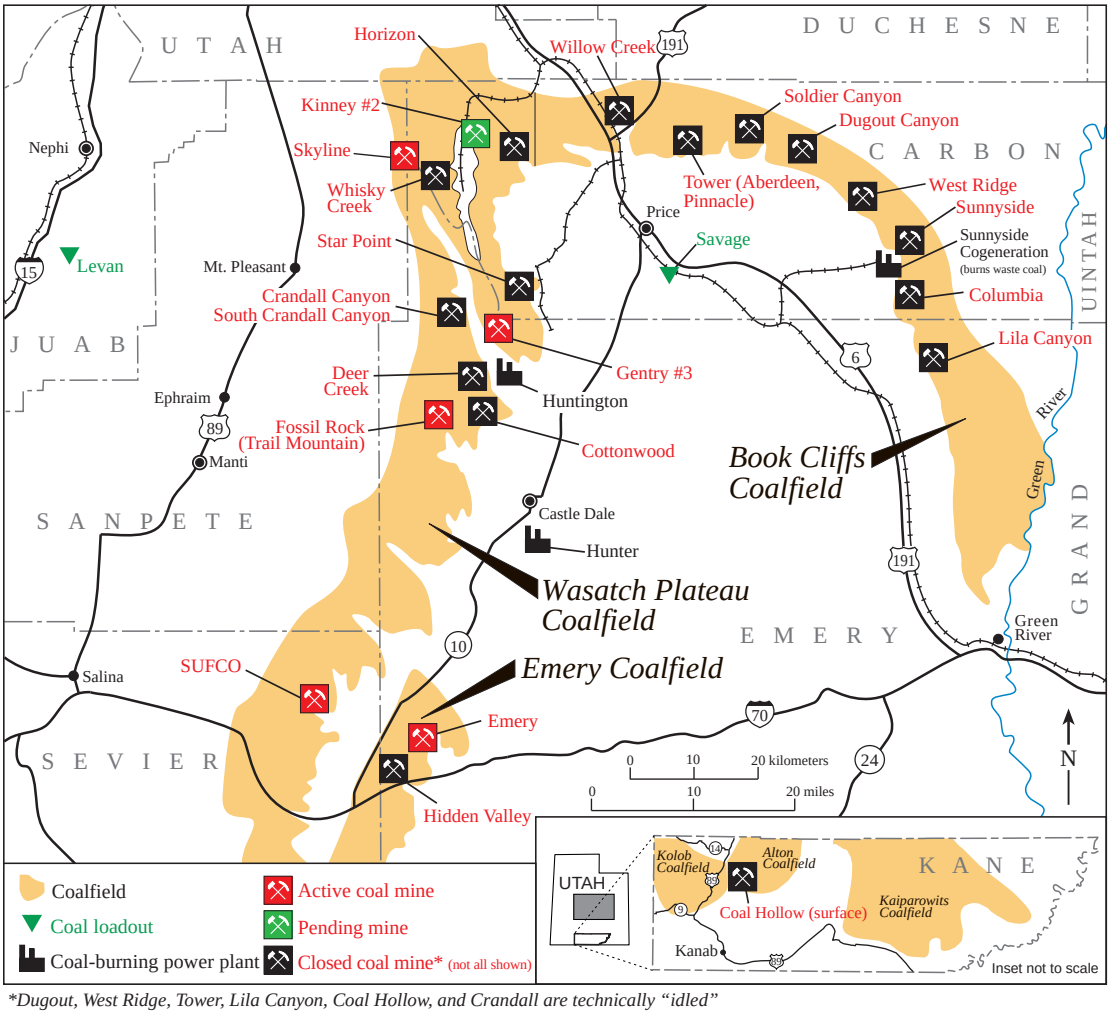


Figure 9 Continued. C) *Utah coal production by county and coal mining productivity, 1985–2024. Data source: Utah Geological Survey and Mines Safety and Health Administration.*



**Dugout, West Ridge, Tower, Lila Canyon, Coal Hollow, and Crandall are technically "idled"*

Figure 10. *Location and status (at time of publication) of Utah coal mines and associated facilities.*

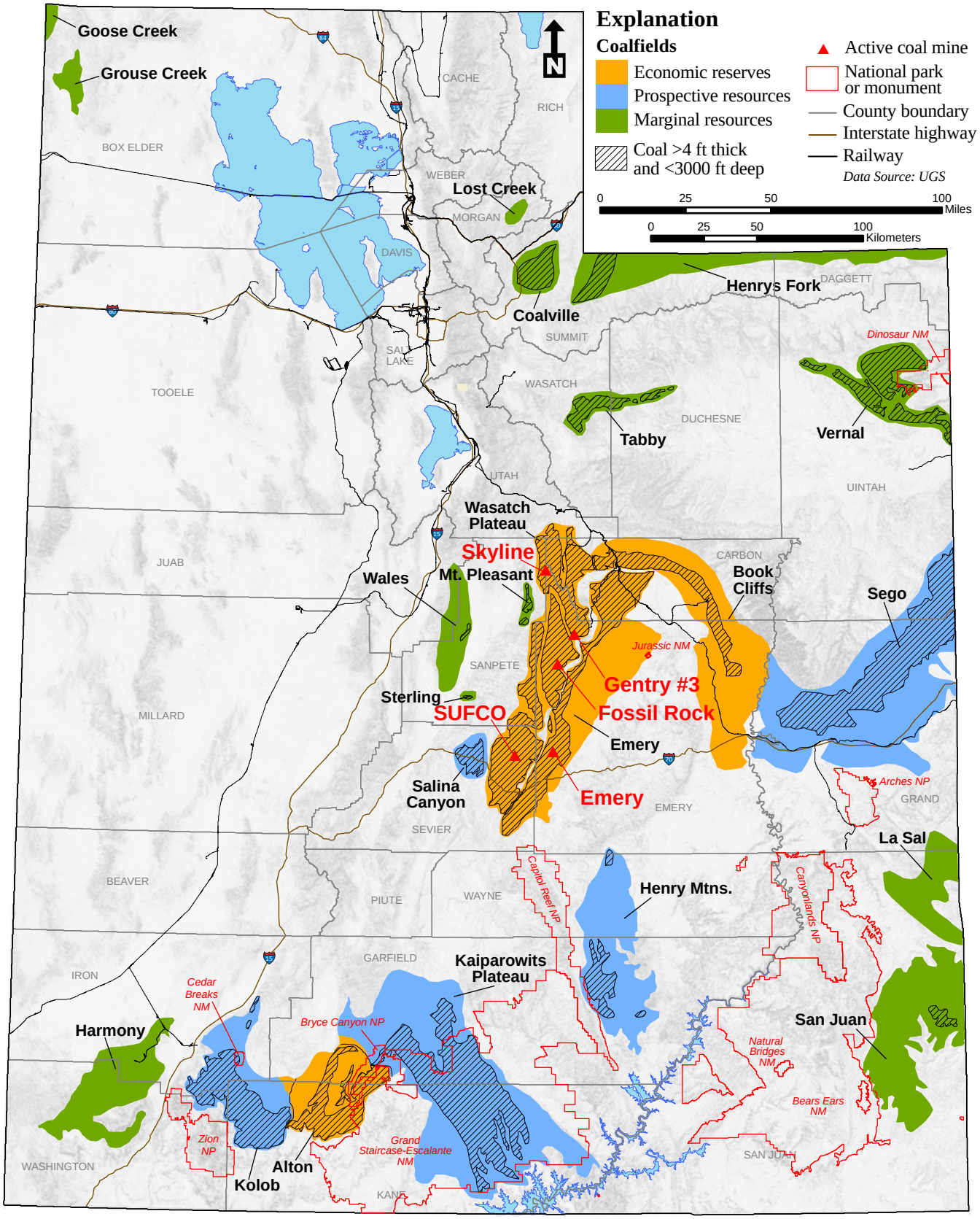


Figure 11. *Location of active Utah coal mines and coalfields.*

Table 3. *Coal production in Utah by coal mine, 2010–2025.*

Company	Mine[1]	County	Coalfield	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025*
				thousand short tons															
Canyon Fuel Company, LLC - Wolverine Fuels, LLC[2]	Dugout Canyon	Carbon	Book Cliffs	2307	2395	1588	561	676	763	650	626	557	430	--	--	--	--	--	--
	Skyline #3	Carbon/Sanpete/ Emery[3]	Wasatch Plateau	3050	2950	1954	3135	4170	4409	4767	4389	3614	3896	3713	3530	2521	2830	2994	3200
	SUFCO	Sevier	Wasatch Plateau	6398	6498	5651	5959	6539	6095	5375	5947	4842	4374	4601	3425	3882	2692	3023	3500
Fossil Rock Resources, LLC - Wolverine Fuels LLC	Fossil Rock (Trail Mtn.)	Emery	Wasatch Plateau	--	--	--	--	--	--	--	--	--	--	--	--	--	--	45	350
Bronco Utah Operations, LLC[4]	Emery	Emery	Emery	999	--	--	4	--	--	--	135	442	694	474	1171	1063	798	1065	1000
Gentry Mountain Mining, LLC - COP Coal Development Co.[5]	Gentry #3	Emery	Wasatch Plateau	--	--	--	--	--	218	170	205	102	562	660	511	600	420	292	300
	Gentry #4	Emery	Wasatch Plateau	--	592	1004	875	1061	757	724	754	893	488	11	--	--	--	--	--
East Mountain Energy - PacifiCorp	Deer Creek	Emery	Wasatch Plateau	2954	3143	3295	2785	2083	15	--	--	--	--	--	--	--	--	--	--
Hidden Splendor Resources, Inc. - America West Resources, Inc.	Horizon	Carbon	Wasatch Plateau	270	370	210	--	--	--	--	--	--	--	--	--	--	--	--	--
Utah Land Resources, Inc. - ACNR Holdings, Inc.[6]	West Ridge	Carbon	Book Cliffs	3355	3566	2579	2629	2514	1580	--	--	--	--	--	--	--	--	--	--
Emery County Coal Resources - ACNR Holdings, Inc.[6]	Lila Canyon	Emery	Book Cliffs	72	157	304	257	335	350	1587	1638	2816	3664	3296	3471	2299	159	--	--
Alton Coal Development, LLC	Coal Hollow	Kane	Alton	--	403	570	747	555	316	671	724	488	240	569	434	354	67	--	--
	Burton #1	Kane	Alton	--	--	--	--	--	11	34	--	--	--	--	--	--	--	--	--
Total				19,405	20,074	17,155	16,953	17,933	14,513	13,978	14,417	13,753	14,347	13,325	12,542	10,719	6966	7418	8350

Source: UGS coal company questionnaire

*Forecast

[1]All mines are underground except Coal Hollow, which is a surface mine.

[2]Bowie Resources bought Canyon Fuel from Arch Coal in summer 2013. In late 2018, Bowie changed their name to Wolverine Fuels.

[3]2024 production by county: Sanpete = 2,050, 743 tons; Emery = 943,117 tons. 2023 production by county: Sanpete = 2,179,666 tons; Emery = 650,486 tons. 2022 production by county: Sanpete = 1,758,956 tons; Emery = 762,244 tons. 2021 production by county: Sanpete = 2,750,773 tons; Emery = 778,989 tons. 2020 production by county: Sanpete = 3,000,319 tons; Emery = 712,681 tons. 2019 production by county: Sanpete = 3,645,133 tons; Emery = 250,695 tons. 2018 production by county: Sanpete = 906,716 tons; Emery = 1,765,410 tons; Carbon = 941,447 tons. 2017 production by county: Sanpete = 43,949 tons; Emery = 136,203 tons; Carbon = 4,208,538 tons. 2010-2016: all production in Carbon County.

[4]Bronco bought the Emery mine from CONSOL Energy in 2015.

[5]COP bought the Castle Valley mines when Rhino went into bankruptcy in late 2020, mines were renamed Gentry. In summer 2010, Rhino bought the Castle Valley mines from C.W. Mining (Co-op); mines were formerly called Bear Canyon.

[6]ACNR Holdings, Inc. was previously Murray Energy.

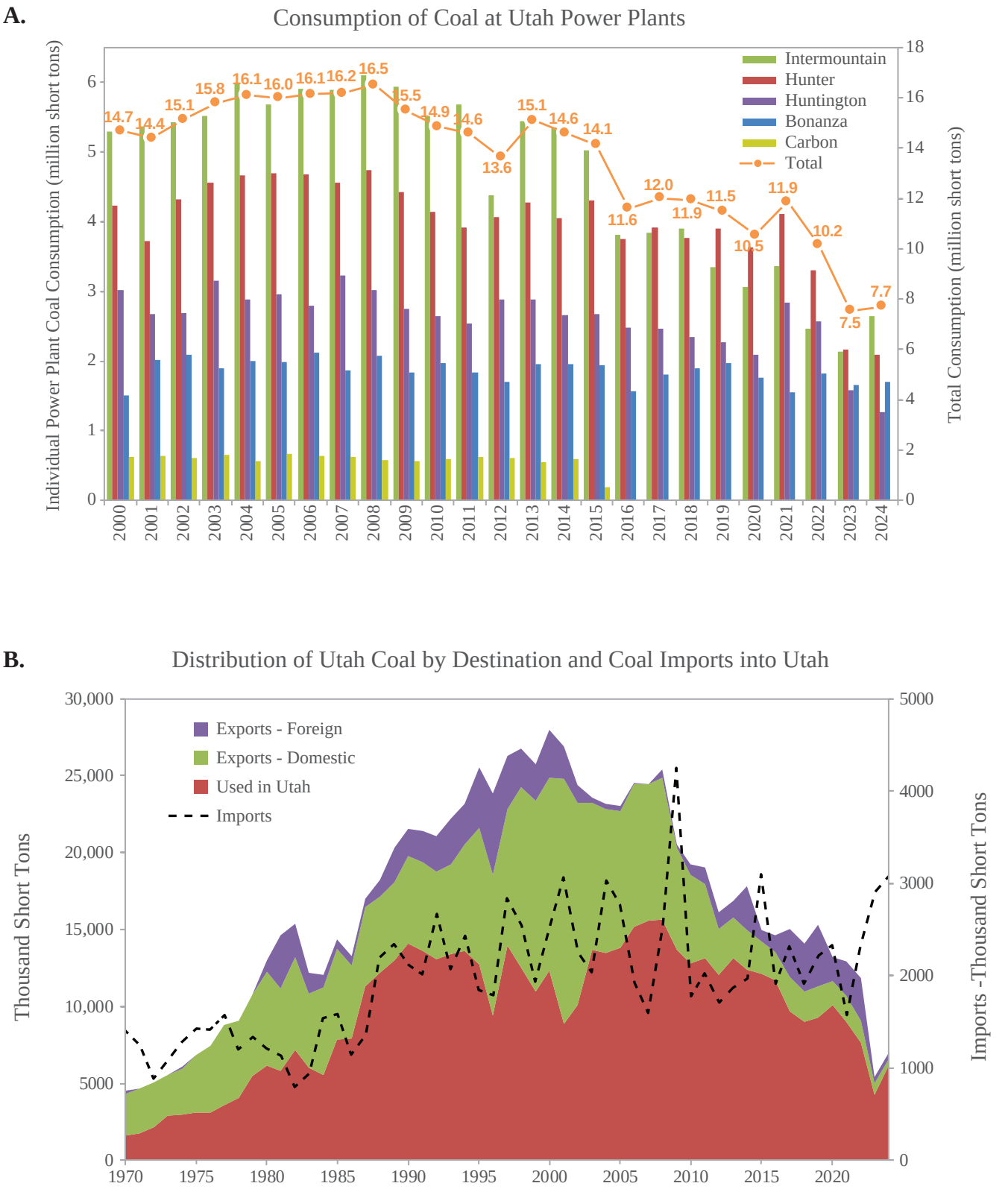


Figure 12. A) *Consumption of coal at Utah power plants, 2000-2024. Data source: U.S. Energy Information Administration. Notes: (1) A generator at the Intermountain Power Plant was offline for several months in 2012, resulting in decreased coal consumption. (2) The Bonanza power plant in Uintah County gets its coal from the Deserado mine just over the border in Colorado. (3) The Carbon plant, Carbon County, shut down in spring 2015. (4) The Sunnyside plant in Carbon County is not included since it burns waste coal.* ***B)*** *Distribution of Utah coal by final destination plotted with Utah coal imports, 1970–2024. Data source: Utah Geological Survey and U.S. Energy Information Administration.*

C.

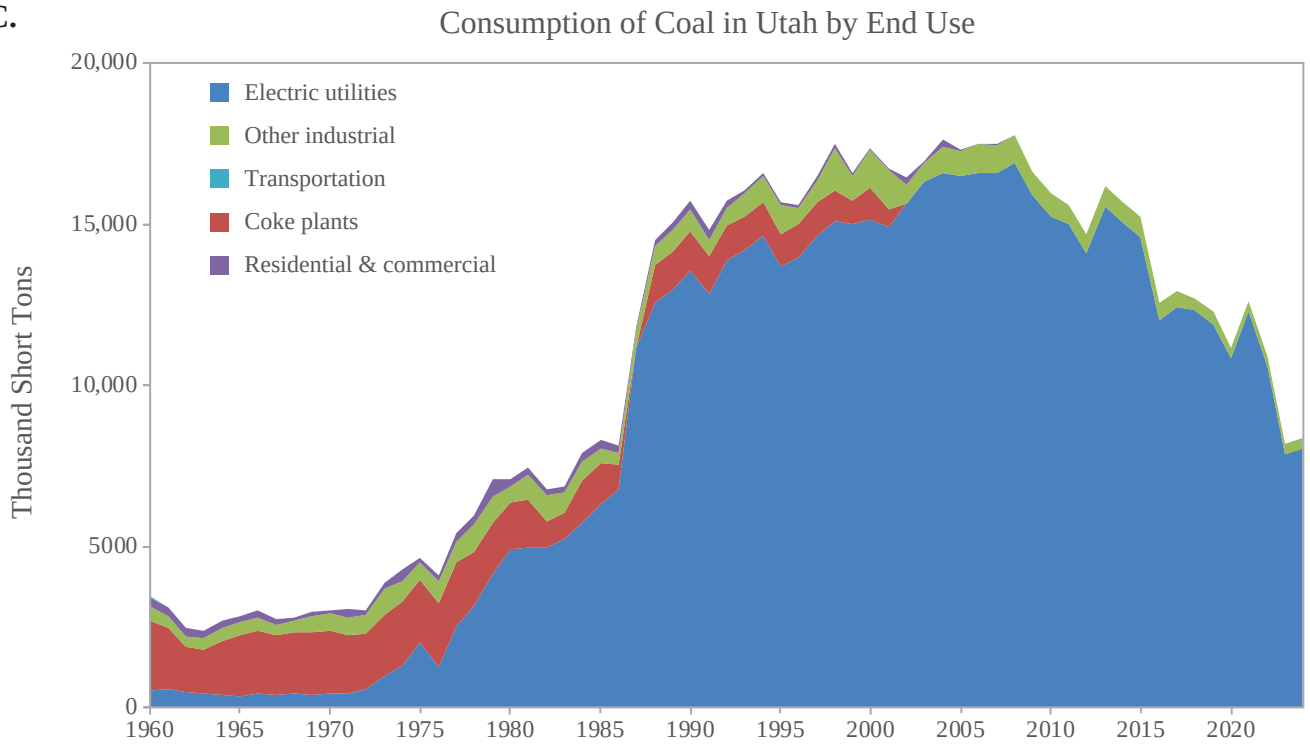


Figure 12 Continued. C) *Consumption of coal in Utah by end use, 1960–2024. Data source: U.S. Energy Information Administration. Notes: Electric utilities includes waste coal burned at Sunnyside.*

Utah power plant consumption dropped significantly again in 2022, to 10.2 Mt, and again in 2023 and 2024, down to 7.5 Mt and 7.7 Mt, respectively. The Intermountain Power Plant continues to ramp down operations and less coal was used at Hunter, Huntington, and Bonanza (burns Colorado coal) as these plants flex power output based on availability of new solar energy resources. Power flexing or closure at other U.S. coal-fired power plants has reduced domestic demand for Utah coal. As recently as 2001, Utah sent nearly 16 Mt of coal to other states, but this number has dropped substantially to just 377,000 t delivered in 2024. Utah operators took advantage of a stronger foreign export market, sending an estimated 2.8 Mt of coal per year overseas to Asia between 2017 and 2022. However, foreign exports decreased to only 386,000 t in 2023 and are expected to remain at that level in 2024 (Figure 12).

During our annual coal mine visits in spring 2025, all mine operators reported softening demand for Utah coal and lower prices (coal prices in Utah averaged $45 per ton in 2023, jumped to $68 in 2024, but are expected to be closer to $40 per ton in 2025). With the recent idling of the Lila Canyon mine, finding staff for current mines has not been as challenging as previous years. The defunding of the coal industry is still an issue and affects the ability for operators to finance new mine equipment and improvements. In addition, several mines are struggling with difficult mining conditions (faults, water, sand channels, dikes, etc.) making it difficult to maintain steady production and keep ash (i.e., rock mined with the coal) levels low. Despite challenging market conditions, Wolverine Fuels began rehabilitation of the old Trail Mountain mine in 2023 (now called Fossil Rock), where they will access the state-owned Cottonwood coal tract. Wolverine recorded some minor production in late 2024 (45,000 t) as redevelopment commenced, making Fossil Rock Utah's first new active coal mine since 2017. As Fossil Rock continues to ramp up operations, and production remains fairly steady at other mines, Utah coal production is expected to increase to about 8.4 Mt in 2025.

For the first time in the history of Utah's coal industry, after the idling of the Dugout Canyon mine in 2019, coal is no longer produced in Carbon County (Figure 9). In contrast, Sanpete County hosted significant coal production for the first time starting in 2017 when operations at the Skyline mine moved to the southwestern Flat Canyon area. Coal production in 2024 came from Emery (2.3 Mt, 32%), Sevier (3.0 Mt, 41%), and Sanpete (2.1 Mt, 28%) Counties.

In 2024, the majority of Utah coal, 6.4 Mt, was produced from the Wasatch Plateau coalfield and 1.1 Mt came from the Emery mine in the Emery coalfield (Table 3). With operations ceasing at both the Lila Canyon mine and the Coal Hollow mine in 2023, there was no production from the Book Cliffs or Alton coalfields in 2024. This marks the first time in the history of Utah coal mining where the venerable Book Cliffs coalfield will record zero coal production.

Nearly all Utah coal production in 2024, 80% (5.9 Mt), was produced from federal land, whereas only 552,000 t (7.4%) was from state-owned land (Figure 9). Federal coal production

has dominated in Utah since 2012, when the now-closed Deer Creek mine's state-owned Mill Fork coal tract reverted back to federal ownership after a 22 Mt coal production threshold was reached. This reversion dramatically increased the amount of coal produced on federal land, from 48% in 2011 to 84% in 2012. The remainder of Utah's 2024 coal production came from private lands (12.4%, 921,000 t) at the Gentry, Emery, and Skyline mines. As the Fossil Rock mine increases production in the Cottonwood tract, state-owned production will significantly increase. The now idled Lila Canyon mine and active Emery mine both experienced changes to surrounding land ownership when the John D. Dingell, Jr. Conservation, Management, and Recreation Act was finalized in early 2025. Significant coal resource tracts near both mines will convert from federal ownership to state (SITLA) ownership, facilitating a more streamlined permitting process for future mining.

The total amount of Utah coal distributed to the U.S. market in 2024 was 6.6 Mt, an increase over the 5.0 Mt distributed in 2023, but much lower than the 12 Mt distributed in 2020 (Figure 12). As recently as 2008, Utah operators distributed 25 Mt of coal; over 9.2 Mt was exported to other states and 16 Mt was used in-state. In 2024, only 377,000 t of Utah coal was shipped to other states, whereas 6.2 Mt was used locally. The vast majority of Utah coal, about 92% (6.1 Mt), went to the electric utility market, mainly within the state. Utah coal deliveries to the industrial sector totaled 545,000 t in 2024, which is significantly less than peak deliveries of 4.4 Mt in 2003. Consumption of coal in Utah is now higher than in-state distribution, indicating that coal imports to Utah were significantly higher than in previous years. Utah power plants consumed 8.1 Mt of coal in 2024 (this includes about 408,000 t of waste coal burned at the Sunnyside power plant) and about 300,000 t used at industrial facilities, the latter being significantly lower than in the 1990s to mid-2010s (Figure 12).

The demand for Utah coal has sharply decreased over the past several years as coal-fired power plants have closed or switched to natural-gas-fired generation. Nationally, operators report that they plan to retire 8.1 gigawatts of coal-fired capacity in 2025, about 4.7% of the coal-fired fleet that was in operation at the end of 2024 (U.S. EIA, 2025b). Within Utah, the Carbon coal-fired power plant outside the town of Helper closed in April 2015 because it was cost prohibitive to retrofit the old plant with new emission-reducing technology. This closure removed about 600,000 t of coal from the Utah market. Between 2016 and 2022, consumption of coal at Utah's remaining coal-fired power plants averaged 11.4 Mt, a 26% decrease from pre-2016 consumption (Figure 12). In 2023, consumption dropped to only 7.5 Mt with only a slight increase to 7.7 Mt in 2024. A significant portion of this reduction occurred at IPP near the town of Delta (peak consumption occurred in 2008 at 6.1 Mt whereas consumption between 2022 and 2024 averaged only 2.4 Mt) as the City of Los Angeles, California, the majority owner, has purchased less electricity from the plant due to favoring mostly renewable energy sources. Los Angeles plans to no longer purchase any coal-fired electricity from IPP after its power purchase agreement expires in 2025, at which time a new plant, currently under construction, will burn a combination of natural gas and "green/blue" hydrogen. It is important to note that the State of Utah is working to keep at least one of IPP coal units operating past 2025. As new solar-generated electricity (mostly from California and Nevada, but also from Utah) floods the grid during the day, Utah's Hunter and Huntington coal-fired power plants have been forced to lower their output during these peak solar times, thus consuming less coal. These two plants consumed an average of 6.9 Mt of coal per year between 1990 and 2022, but have only consumed 3.7 Mt in 2023 and 3.4 Mt in 2024. Overall, reductions in coal demand have had a profound impact on Utah coal mining operations, and low demand and uncertainty will continue into the future.

Foreign exports of Utah coal averaged 2.9 Mt per year in the 1990s, peaking at 5.3 Mt in 1996 (Figure 12). Beginning in the early 2000s, foreign exports dropped dramatically, with no exports reported in 2007. Starting in 2008, Utah coal exports revived, reaching 2.9 Mt in 2014, before dropping again in 2015 to only about 0.7 Mt and 1.0 Mt in 2016. High demand and high international prices spurred increased exports between 2017 and 2022, but prices softened significantly in 2023 resulting in much fewer export opportunities (386,000 t in 2023 and an estimated 400,000 t in 2024). With diminished port capacity on the West Coast of the United States, Utah operators have sought out alternate port facilities (e.g., Gulf of Mexico) to send their coal overseas, but this is only economic when international prices are high.

For detailed statistics on Utah's coal industry (including information previously published in the annual Utah Coal Report), refer to the data tables located on the UGS's Utah Energy and Mineral Statistics website: http://geology.utah.gov/resources/energy/utah-energy-and-mineral-statistics/.

Coal Exploration/Development Updates for 2024/2025

- Lila Canyon mine: Production halted in September 2022 when a "thermal event" was detected in a mined-out area of the underground workings. After extensive work to extinguish the fire, miners re-entered the mine in early 2023, but rehabilitation efforts were unsuccessful. The mine was "indefinitely idled" in late 2023 after minor production of 159,000 t for the year. Significant coal reserves are still present in the area, most notably the Williams Draw tract to the south, which recently transferred to State ownership via the Dingell Act.

- Gentry mine: COP Coal Development, LLC, bought the Castle Valley mines when Rhino Resources went into bankruptcy in late 2020—the mines were renamed Gentry. Gentry mine #4 was closed in early 2020 and all mining now takes place in the Gentry #3 mine, currently

from the Hiawatha seam. Challenging geology will keep production lower than previous years, with an estimated 2025 total of about 300,000 t. Significant reserves to the west and north are available.

- Emery mine: Production at the Emery mine more than doubled in 2021 as four continuous miner machines were brought online and this level of production continued into 2022 (about 1.1 Mt), decreased slightly in 2023 to 798,000 t, but ramped back up in 2024 to 1.1 Mt. With the finalization of the Dingell Act new coal reserves in the Walker Flat area have been transferred to State (SITLA) jurisdiction, and Emery hopes to start mining this area next year.

- Sufco mine: Longwall development shifted to the federal Greens Hollow tract while production finished in the federal Pines district to the northeast (finished in spring 2023). Longwall production in Greens Hollow started in 2024 with production reaching 3.0 Mt, and 2025 production is expected to reach 3.5 Mt.

- Skyline mine: Operations at the Skyline mine shifted to the Lower O'Connor B seam in the Flat Canyon area in 2017. Complicated geology (e.g., faults, water infiltration, etc.) caused less production in 2022, down about 1 Mt from 2021, but production rebounded back to 2.8 Mt in 2023 and 3.0 Mt in 2024. With continued investment in water handling and inseam exploration drilling, production at Skyline will continue and is expected to reach 3.2 Mt in 2025.

- Fossil Rock mine: This mine is owned by Fossil Rock Resources, LLC, a subsidiary of Wolverine Fuels. This SITLA coal tract contains nearly 50 Mt of mineable coal in the Hiawatha seam. Wolverine re-entered the closed Trail Mountain mine in 2023 and completed necessary rehabilitation in mid-2024. A small amount of coal was produced in 2024 (about 45,000 t) as continuous miner machines started development in the new workings. Production in 2025 is expected to be about 350,000 t as longwall development continues, with full-scale production starting in early 2026 and yielding up to 3.0 Mt of coal per year. Difficult mining conditions (e.g., "spars" or clastic dikes) will need to be addressed as mining continues.

- Coal Hollow mine: Alton Coal Development has completed mining on the northern private lease as well as the areas to the south which are private at the surface, but contain federal coal. The mine was idled in mid-2023 (and remains idle to date) after producing only 67,000 t due to delays in permitting an additional federal block to the west of the current facilities.

- Kinney #2 mine: Coal Energy Group 3, LLC have submitted a new permit application for the Kinney #2 mine (mid-January 2025), located just east of the town of Scofield, Utah, in the Wasatch Plateau coalfield. Underground mining via continuous miner machines is planned in the Hiawatha seam on roughly 452 acres. The permit was open for public comment through mid-April 2025, and the Utah Division of Oil, Gas and Mining is reviewing those comments.

ACKNOWLEDGMENTS

This report was compiled from a wide assortment of published and unpublished sources. In addition, we particularly appreciate the cooperation and assistance of Bronco Utah Operations, Utah Division of Oil, Gas and Mining (Kim Coburn), COP Coal Development, SITLA (Andy Bedingfield), Wolverine Fuels, and the many companies that responded to the 2024 UGS production and exploration surveys.

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EXHIBIT 50

History

Utah Department of Transportation (UDOT) completed multiple projects on the U.S. Route 191 Indian Canyon Corridor between US-40 and US-6 during 2023 and 2024. Improvements to the corridor will continue during 2025 and 2026 to ensure the road withstands the projected additional heavy vehicle traffic and to improve safety for all travelers on the route. The 45-mile corridor runs from Duchesne to Helper.

Nearly $104 million has been allocated for improvements to the corridor. The Utah Legislature appropriated $88.5 million in their 2023 session, and UDOT has provided just over $15.49 million in additional state and federal funding for improvements to the US-191 Indian Canyon corridor.

During the 2024 construction season, three projects were completed:

A new southbound passing lane on US-191 between mileposts 280 to 282
A pavement preservation project that placed fresh pavement, updated existing guardrails, and installed four cattleguards at multiple locations on US-191 from US-6 to US-40
Improvements to the intersection of US-191 and US-6

Public Open House Meeting Materials

Completed Projects

- December 2025 - North of Summit Improvements
- October 2025 - US-191 and US-40 dedicated right-turn lane
- August 2025 - US-191 and US-40 traffic signal installed
- October 2024 - US-6/US-191 intersection improvements
- August 2024 -Construction on soutbound passing lane (MP 280-282)
- Spring 2023 - Design for southbound passing lane (MP 280-282)

Give Feedback

EXHIBIT 51



July 2025

Wildcat Loadout Facility Right-of-Way Amendment

Environmental Assessment **DOI-BLM-UT-2025-0015-EA**

Consumers Road, Carbon County Utah
Salt Lake Meridian,
Township 13 South, Range 9 East
Section 33, SWNE, SENW, E1/2SW1/4

U.S. Department of the Interior
Bureau of Land Management
Price Field Office
120 South 600 West
Price, Utah 84501

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CHAPTER 1. INTRODUCTION

1.1. Background

Project proponent Coal Energy Group 2, LLC (CEG2) is the current holder of a Bureau of Land Management right-of-way (ROW) where the Wildcat Loadout Facility is located, UTUT106262560 (legacy number UTU-48027). (See Figure 1-1).

The BLM first issued the Wildcat Loadout Facility ROW in 1982 for the purpose of transloading coal from trucks to railway cars. The coal transloading facilities remain at the ROW but are no longer functional and have been idled since 2016.[1] In 2013, the ROW holder began transloading oil using mobile facilities under 43 CFR 2801.5 (b). In 2014, the BLM authorized development of permanent transloading facilities on the west side of the ROW for crude oil (DOI-BLM-2013-0063-EA). The developments listed in Table 1-1 were analyzed and approved in 2014:

Table 1-1: Modifications/Additions approved in the 2014 EA

Permanent Modifications/Additions Approved in 2014 EA
2 - 100,000-barrel crude oil storage tanks and 2 - 20,000-barrel crude oil storage tanks
1 - 5,000-gallon tank containing water with foam/fire suppressant
4 - Stationary truck unloading lanes (truck to storage tank)
4 - Fixed pumps with piping to load from truck to tank
Up to 4 - Additional loading railway tracks
1 - Additional dual-sided loading railway track
1 - Vapor Combustion Unit (VOC), smokeless, natural draft assisted, and enclosed vapor combustor
1 - Drainage ditch and two proposed sediment ponds for runoff
12 - Down shielded light posts at truck unloading lanes, tank area, and railcar loading tracks
71 - Light pollution shields for existing lights
1 - Transformer substation
1 - 10,000-gallon self-contained diesel fuel tank adjacent to truck unloading lanes

[1] *The coal loadout operation involved three truck dumps, a railway car loading track, and various conveyor belts, as well as structures to facilitate reclaiming, crushing, storing, and loading coal. The mine that historically used the coal transloading facilities is closed, abandoned, and in the process of being reclaimed. If the ROW holder wants to resume coal transloading operations at the ROW, it would need further authorization from BLM (in a new, appealable decision) to reconfigure and upgrade the coal transloading facilities.*

Companies currently under contract with the Wildcat Loadout Facility[2] have oil tanker trucks that load crude oil at their wells in Duchesne and Uintah counties, then transport the oil along various oil field and local roads, Highways 40, 191, and 6, and Consumers Road to the Wildcat Loadout Facility (see Figure 1-2). The oil tanker trucks enter the Wildcat Loadout Facility utilizing an access road on the west side of rail tracks. Crude oil is then transferred from the oil tanker trucks to the railway cars utilizing mobile pumping stations. Once approximately thirty-five (35) loaded railway cars are assembled into a unit, Utah Railway transports the unit to the Martin Yard in Helper, Utah. Three units (one-hundred four (104) railway cars) are assembled into a train at the Martin Yard, and then enter the Union Pacific, and the Burlington Northern Santa Fe Railways railway system for shipment to refineries in Texas and Louisiana on the Gulf Coast (see Figure 1-3).

CEG2 proposes to amend the ROW to reconfigure and expand its transloading facilities at the Wildcat Loadout Facility. The modifications would change the site layout and add facilities such as an oil tanker truck, unloading racks, oil storage tanks, a vapor combustion unit, railway car loading racks, and a motor control unit within 30 acres of previously disturbed lands within their current 270-acre ROW. Although many of these developments and changes were part of the 2014 decision, some were never installed due to geotechnical testing of the soils and because most facilities would have occurred in a stormwater retention/infiltration basin. The newest proposal changes the location of these facilities to be located on the east side of the ROW in part to address the earlier soils and stormwater issue, and to allow safer traffic flow on and off Consumers Road. Table 1-2 compares the 2014 approval to the 2025 application.

Table 1-2: Comparison of Facilities between the 2014 EA and the 2025 Application

Modifications/Additions Approved in 2014 EA for the West Side of the Tracks	**Status [3]**	**2025 application Proposed Modifications/Additions for the East Side of the Tracks**
2-100,000-barrel crude oil storage tanks and 2-20,000-barrel oil storage tanks	Never installed	2-heated, 80,000-barrel crude oil storage tanks
1-5,000-gallon tank containing water with foam/fire suppressant	Installed	No change
4-stationary, dual-sided truck unloading lanes	Never installed	10-stationary, dual-sided truck unloading lanes
4-fixed pumps with piping at the unloading lanes to load from truck to tank	Never installed	10-fixed electric pumps and piping at the unloading lanes to transfer from truck to tank
Up to 4-additional rail tracks	Installed 1 rail track	3-additional rail tracks
1-dual-sided railway car loading rack	Never installed	12-dual-sided railway car loading racks
1-Vapor combustion unit that would be 96 inches in diameter by 20 feet high	Never installed	1-Vapor combustion unit that would be 96 inches in diameter by 40 feet high

[2] The primary shippers using the Wildcat Loadout Facility are Uinta Wax Operating, LLC, Finley Resources, Inc, Scout Energy Management, LLC and Wasatch Energy Management, LLC, however the facility is open to any producers that need to transport their product.

[3] CEG2 will not install anything approved in 2014 that has not already been installed. The currently submitted Plan of Development (POD), if approved, will become the POD for the ROW, and the other decision will be replaced.

Modifications/Additions Approved in 2014 EA for the West Side of the Tracks	Status [3]	2025 application Proposed Modifications/Additions for the East Side of the Tracks
1-Drainage ditch and 2-proposed sediment ponds for runoff	Installed	Fill in 1 pond and extend a second, move a topsoil pile and remove a culvert to accommodate the trucks
Approximately 12-new down shielded light-posts at truck unloading lanes, tank area, and railcar loading tracks	Not installed	10-lights for truck unloading lanes, 15-lights for railway car loading racks, tank lighting, 13-lights for transfer pump, 1-light at vapor combustion unit. All lights would be down shielded.
71-Light pollution shields for existing lights	Installed	No change
1-Transformer substation	Installed	No change
1-10,000-gallon self-contained diesel fuel tank adjacent to truck unloading lanes	Installed	No change
N/A	N/A	1-Motor Control Center
N/A	N/A	3-electric pumps for loading from tank to railway car and one electric pump as a "hot spare" for pumps taken out of service for maintenance or repairs

In 2024, Utah Candle Company, LLC acquired a 30-year lease from the Utah Trust Lands Administration (TLA) on 51.61 acres of TLA lands adjacent to the Wildcat Loadout Facility (see Figure 1-4). Wildcat Loadout has an agreement with Utah Candle Company, LLC to expand the Wildcat Loadout Facility onto this lease should BLM reject their ROW amendment request.

On May 1, 2025, CEG2 requested that BLM process its Wildcat Loadout Facility ROW amendment under alternative arrangements for NEPA compliance.[4] On June 19, 2025, the request was approved by the Acting Assistant Secretary – Land and Minerals Management.

This Environmental Assessment (EA) has been prepared to analyze the potential impacts to the environment that could result from implementation of the Proposed Action, as compared to the No Action Alternative.

[4] *The President issued Executive Order (EO) 14156 "Declaring a National Energy Emergency" on January 20, 2025, which directed heads of executive departments and agencies to "facilitate the … transportation, refining, and generation of" energy resources on Federal lands. Secretary's Orders No. 3417 and 3418 implemented provisions of EO 14156 and directed Bureaus and Offices under the Department of the Interior to identify any emergency authorities to facilitate "energy projects" as defined by EO 14156. On April 23, 2025, the Council on Environmental Quality (CEQ) authorized the use of alternative arrangements to comply with the National Environmental Policy Act (NEPA) before taking urgently needed actions (43 Code of Federal Regulations (CFR) 46.150) for projects that respond to the national energy emergency.*

Figure 1-1: Wildcat Loadout Facility

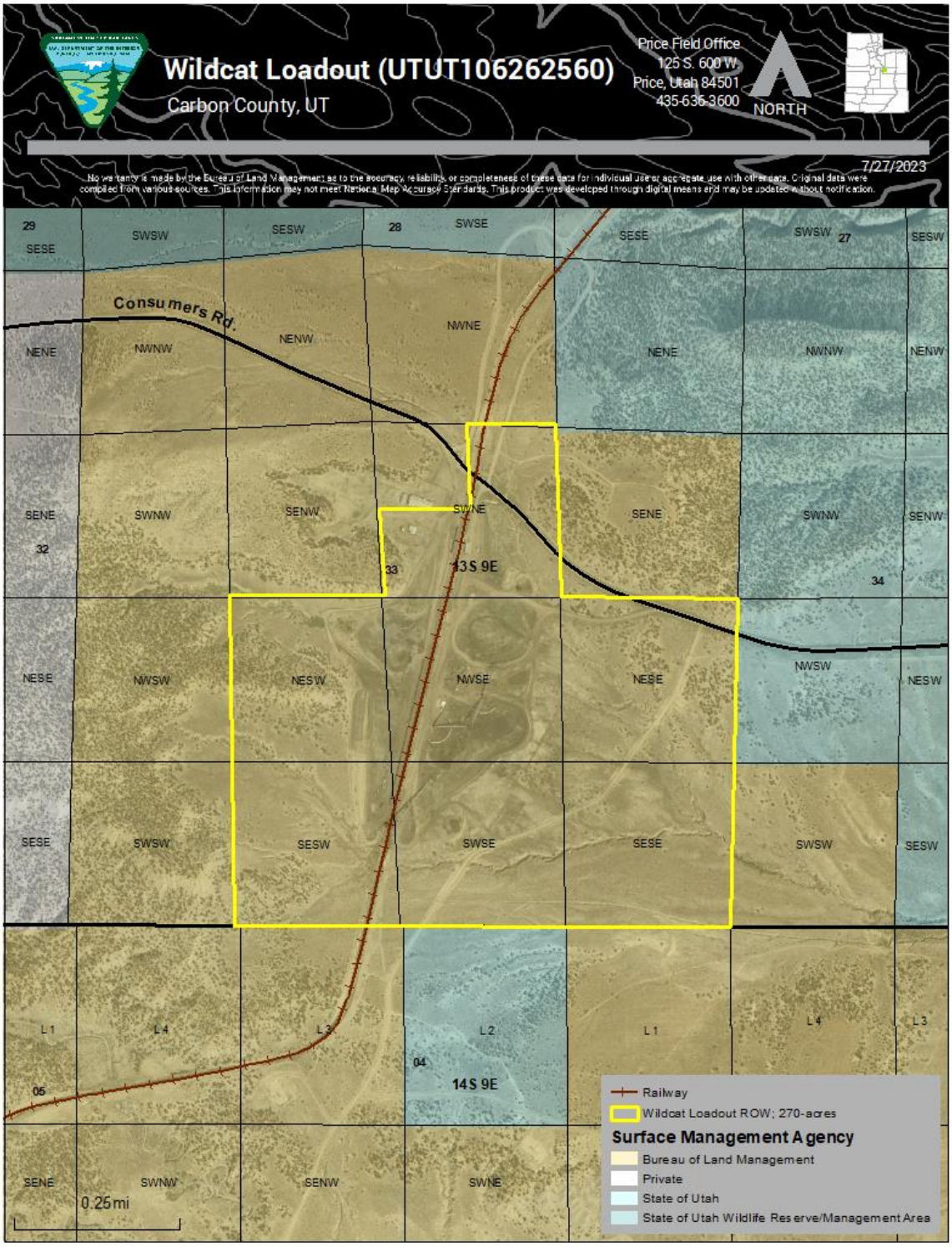


Figure 1-2: Oil Tanker Trucks Transportation Routes

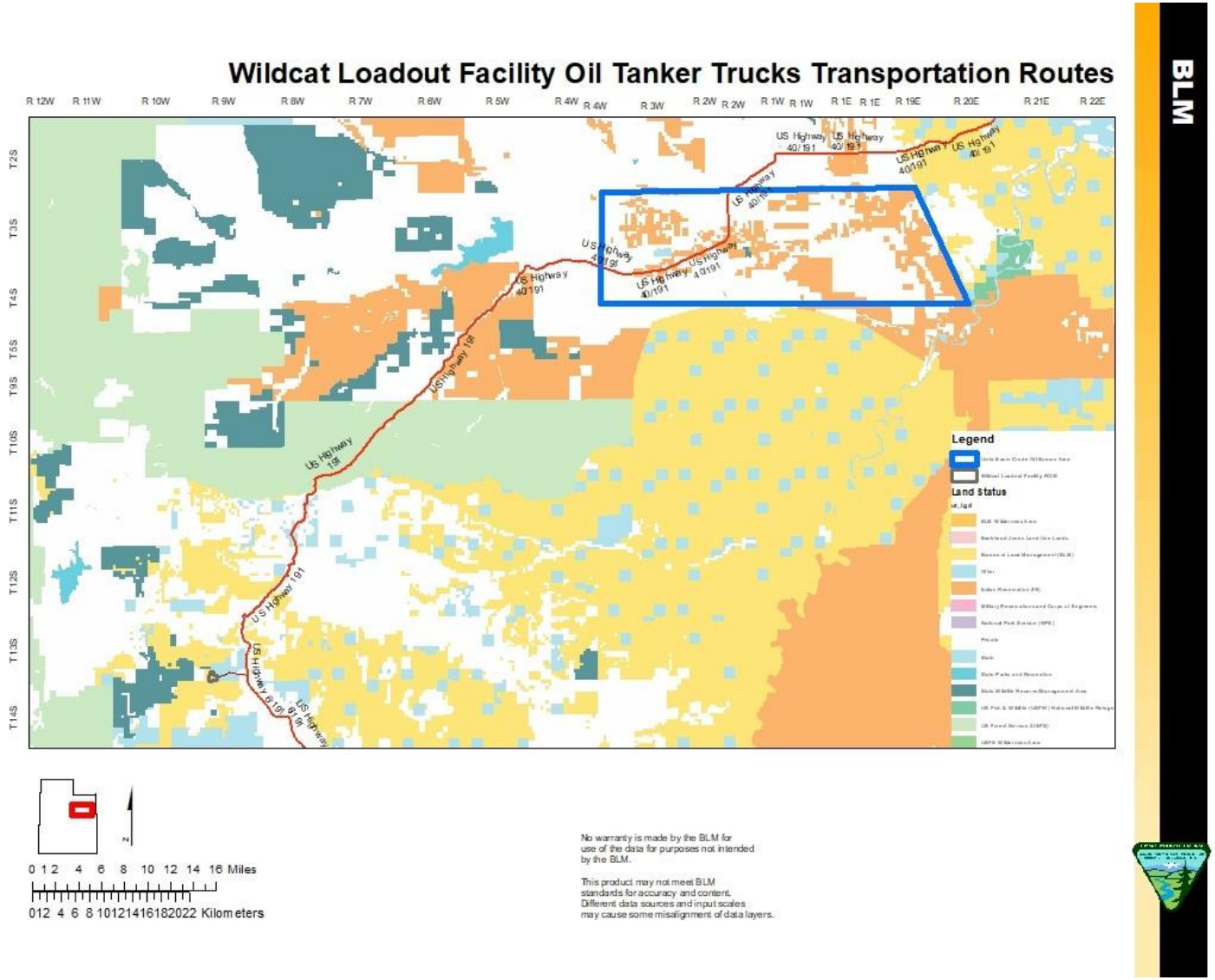
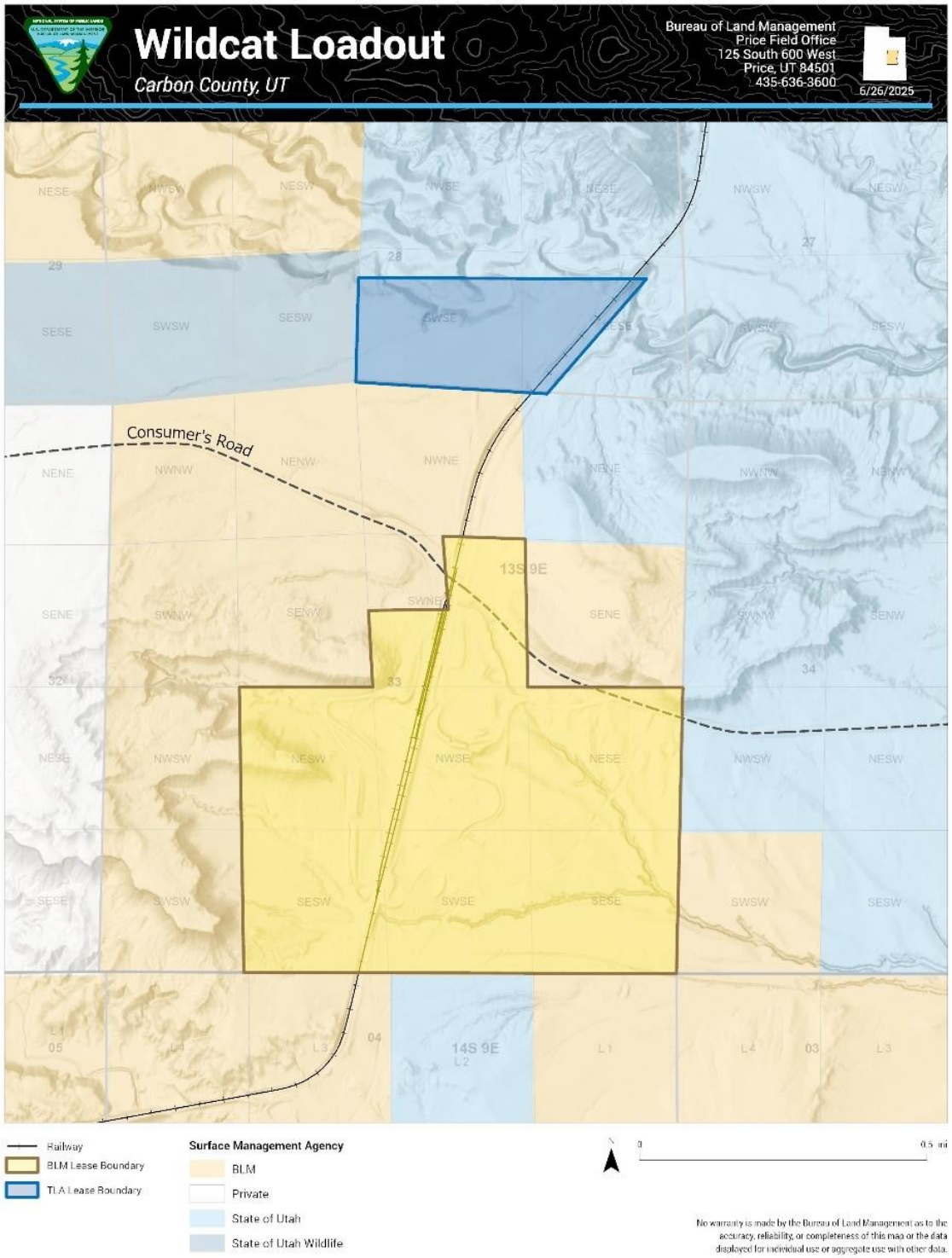


Figure 1-3: Railway Transportation Routes



Figure 1-4: Leased TLA Lands Adjacent to Wildcat Loadout Facility



1.2. Purpose and Need

The purpose and need of the federal action are to consider an application for an amendment to ROW UTUT106262560 to change the facility layout and add facilities. The need is BLM's statutory and regulatory responsibilities regarding ROW applications under Title V of the Federal Land Management and Policy Act of 1976 (FLPMA) as amended, and 43 CFR Part 2800.

1.3. Decision to be Made

The BLM will decide whether to grant or deny the ROW amendment, which serves as the authorization for the proposed modification, and under what terms and conditions.

1.4. Conformance with the Land Use Plan

Land Use Plan Name: Price Field Office Record of Decision (ROD) and approved Resource Management Plan (RMP) as amended by the 2015 Utah Greater Sage Grouse Approved Resource Management Plan Amendment.

Date Approved: October 2008

The Proposed Action is in conformance with the applicable land use plan because it is consistent with the RMP decision(s) (objectives, terms, and conditions) listed in Table 1-3.

Table 1-3: Conformance with the Land Use Plan

RMP decision(s) (objectives, terms, and conditions)	How the project conforms
Lands and Realty (LAR) Objective: Maintain availability of public lands to meet the habitation, cultivation, trade, mineral development, recreation, and manufacturing needs of the external customers and the general public (page 115).	The project would provide additional transloading capacity for developed minerals (crude oil) to additional markets.
LAR-28: Additional ROWs will be granted consistent with RMP goals and objectives.	The project would be a ROW amendment.
MA-LR-5: In GHMA, manage ROWs, permits, and leases as follows (Figure 2-11): □ Open: 484,900 acres □ Avoided: 0 acres □ Excluded: 17,600 acres New ROWs (including permits and leases) authorizations will be allowed if they apply the pertinent management for discretionary activities in GHMA identified in MA-SSS-5.	The Proposed Action is a modification of an existing ROW in an area open to ROWs. In addition, MA-SS-5 (net conservation gain, buffers, and required design features) does not apply because it is not a new ROW.

1.5. Relationship to Statutes, Regulations, Policy, Orders, and other Plans

The Proposed Action is related to the statutes, regulations, policies, orders and other plans are directly listed in Table 1-4.

Table 1-4: Relationship to Statutes, Regulations, Policies, Orders and other Plans

Statutes, Regulations, Policies, Orders and other Plans	How the Project Relates
FLPMA of 1976, as amended, Title V and its implementing regulations at 43 CFR 2800	The project is a FLPMA Title V ROW modification on Federal Lands.
Utah Greater Sage-Grouse Approved Resource Management Plan Amendment.	The ROW is in lands identified as General Habitat Management Area (GHMA) for Greater Sage-grouse.
Transportation regulations at Title 49 of the Code of Federal Regulations	Crude oil that would be transported by oil tanker truck or railway car and transloaded through the facility is under the jurisdiction of the Department of Transportation (oil tanker trucks), the Federal Railroad Administration (railway cars) and the Pipeline and Hazardous Materials Safety Administration (hazardous materials).
Clean Air Act (CAA) of 1970 and its Conformity Regulations at 40 CFR 93B	The project transports crude oil originating in the Uinta Basin's nonattainment area. Oil production in the Uinta Basin is subject to the CAA conformity regulations.
Clean Water Act (CWA) of 1973 and its Spill Prevention Control and Countermeasure (SPCC) regulations at 40 CFR 112.7 which regulate oil storage spill prevention and response.	The installation of storage tanks would include earthen berms constructed around them to conform with the SPCC Plan for the Wildcat Loadout Facility site.
Utah Department of Water Quality Storm Water Permits	The project requires a permit from Utah Department of Water Quality regarding handling of stormwater on industrial facilities.
Utah Division of Air Quality (DAQ) New Source Review Permits	The project requires a permit from Utah DAQ regarding handling of emissions from industrial facilities. CEG2 holds a Utah DAQ Approval Order for the facility.
Utah Resource Management Plan (2024)	The project falls within the Utah Resource Management Plan's commitment to have Utah support national energy independence.
Carbon County Resource Management Plan (2022)	The project falls with Carbon County Resource Management Plan's policy to maintain existing access without any restrictions or impediments other than those which are naturally occurring, such as winter closures, landslides, or other events which are beyond the control of man. Carbon County's Resource Management Plan defines access as all modes of transportation including improvements to get product to market.
EO 14156, Declaring a National Energy Emergency, implemented by Secretary's Order 3417, Addressing the National Energy Emergency	The proposed ROW modification would transload domestic crude oil from truck to train for transportation to market. On May 1, 2025, CEG2 submitted a request in writing to BLM to use the alternative arrangements for NEPA compliance. On June 19, 2025, their request was approved.
EO 14154, Unleashing American Energy, implemented by Secretary's Order 3418, Unleashing American Energy	The proposed ROW modification would facilitate transloading of domestic crude oil from truck to train for transportation to market.

1.6. Scoping and Issues

During the internal scoping process, the BLM Interdisciplinary (ID) Team reviewed the SF-299 and Plan of Development for the proposed ROW amendment and completed an ID Team checklist to identify issues related to resource values and land uses that could be affected. Under the alternative arrangements being used for NEPA compliance because of the national energy emergency described in EO 14156, the Responsible Official is not required to seek public comment prior to finalizing the EA, finding of no significant impact, or any decision. The project was listed on the BLM National NEPA Register on June 18, 2025.

The BLM ID team identified the following issues as requiring detailed analysis in the EA.
Issue 1: What impacts would occur because of the increase in Consumers Road truck traffic?
Issue 2: What impacts would occur because of the increase in rail traffic between Wildcat Loadout Facility and Martin Yard?

The BLM also analyzed in brief an additional 26 issues and determined a detailed analysis was not warranted for these issues for the reasons discussed in Appendix A. The brief analysis includes a concise discussion regarding the affected area and degree of impacts related to each issue. Those resources listed in Appendix A were determined to have no potential for significant impacts.

Some resources are not associated with potential issues because they are not present or would not be impacted appreciably by the Proposed Action. Those resources are listed in Table 1-5 along with explanations concerning why no analysis is needed.

Table 3-1-5: Resources for Which No Analysis is Necessary

Resource	Rationale for Why No Analysis is Necessary
BLM Natural Areas	Per BLM Utah Corporate Data review, the nearest natural area is the Mexican Mountain Wilderness Characteristic Protection Area, located 43 miles away.
Designated Areas: Areas of Critical Environmental Concern (ACEC)	Per review of the BLM National Dataset, the nearest ACEC is the Cleveland Lloyd Dinosaur Quarry ACEC, 26 miles away.
Designated Areas: Wild and Scenic Rivers (WSR)	Per review of the BLM National Dataset, the nearest WSR is the Green River Wild Segment, 53 miles away.
Wilderness	Per review of the BLM National Dataset, the nearest wilderness is Desolation Canyon Wilderness in Emery County, 35 miles away.
Jurassic National Monument (JNM)	Per review of the BLM National Dataset, the project is located 25 miles from JNM.
National Historic Old Spanish Trail	Per review of the BLM National Dataset, the project is located 31 miles from the Old Spanish Trail.
San Rafael Swell Recreation Area	Per review of the BLM National Dataset, the project is located 31 miles from the Recreation Area.
Wilderness Study Areas (WSAs)	Per review of the BLM National Dataset, the nearest WSA is Desolation Canyon WSA in Carbon County, 38 miles away.
Lands with Wilderness Characteristics	Per BLM Utah Corporate Data review, the proposed ROW is not within a lands with wilderness characteristics unit. The nearest inventoried unit, Price River, is 20 miles away.
Plants: BLM Sensitive	Based on GIS review, elevation, geology data and occurrence records, there are no BLM sensitive plant species or habitat present in the area. The closest known habitat is located approximately 7 miles to the southeast.

Resource	Rationale for Why No Analysis is Necessary
Plants: Threatened, Endangered, Proposed, or Candidate	Based on GIS review, elevation, geology data and occurrence records, there are no Threatened, Endangered, Proposed or Candidate plant species or habitat present in the area. The closest known habitat is located approximately 8 miles to the southeast.
Water: Water Rights	Per review of Utah Division of Water Rights dataset, there are no Water Rights within the ROW. Within a 1-mile radius of the ROW there are approximately 3 water rights per review of Utah Division of Water Rights dataset. The water rights are upstream and in the next drainage over from the ROW. No withdrawal is occurring for the ROW. Due to the flow direction and topography of the water rights in relation to the ROW, there is no potential for impacts that warrant detailed analysis.
Wild Horses	Review of GIS data shows that the ROW is not within a Wild Horse or Burro Herd Management Area. The nearest herd management area (Range Creek) is 30 miles away.
Woodlands/Forestry	According to site visit and the Price Field Office (PFO) RMP there are no woodland/forestry products within the ROW as it has been previously disturbed and has been not identified as an area for harvest of woodlands/forestry products.

CHAPTER 2. DESCRIPTION OF ALTERNATIVES

This chapter describes the alternatives considered by the BLM during preparation of this EA. The BLM analyzed two possible alternatives: Alternative A - No Action Alternative and Alternative B - Proposed Action. Each alternative describes the proposed expanded facilities at the Wildcat Facility ROW. Transportation routes are common to both alternatives and are described in section 1.1 (see Figures 1-2 and 1-3).

2.1. Alternative A – No Action

Under the No Action alternative, the BLM would deny the ROW amendment application, and crude oil truck-to-train transfer would continue as is currently occurring at the Wildcat Loadout Facility. The ROW grant would expire on December 31, 2034. For pictures of the existing Wildcat Loadout Facility and TLA Loadout Development, see https://wildcatmidstream.com/. If BLM denies the application, CEG2 will construct the proposed facilities on the adjacent 51.61-acre TLA parcel instead (see section 3.2.1).

2.1.1. Existing Wildcat Loadout Description

Under the No Action alternative, the operation at the Wildcat Loadout Facility would continue as currently approved. The operations occur 24 hours a day, seven days a week. These operations are described in the following subsections. Figures 2-1, 2-2, and 2-3 are Google Earth aerial photographs of the existing operations layout. Figure 2-1 shows Consumers Road (green line), the Wildcat Loadout Facility, and the railway between the Wildcat Loadout Facility and the Martin Yard (grey line). Figure 2-2 shows the existing Wildcat Loadout Facility layout. Figure 2-3 shows the existing rail layout and a truck transloading into a railway car.

The ROW expires on December 31, 2034, but CEG2 may request to renew the ROW prior to expiration.

CEG2 employs approximately 32 full time employees. Many ancillary jobs (such as oil tanker truck contractors) are also supported by the operation. The operations that would occur on the TLA leased lands are anticipated to require up to 13 more employees.

Figure 2-12: Consumers Road, Wildcat Loadout Facility, and Railway to Martin Yard

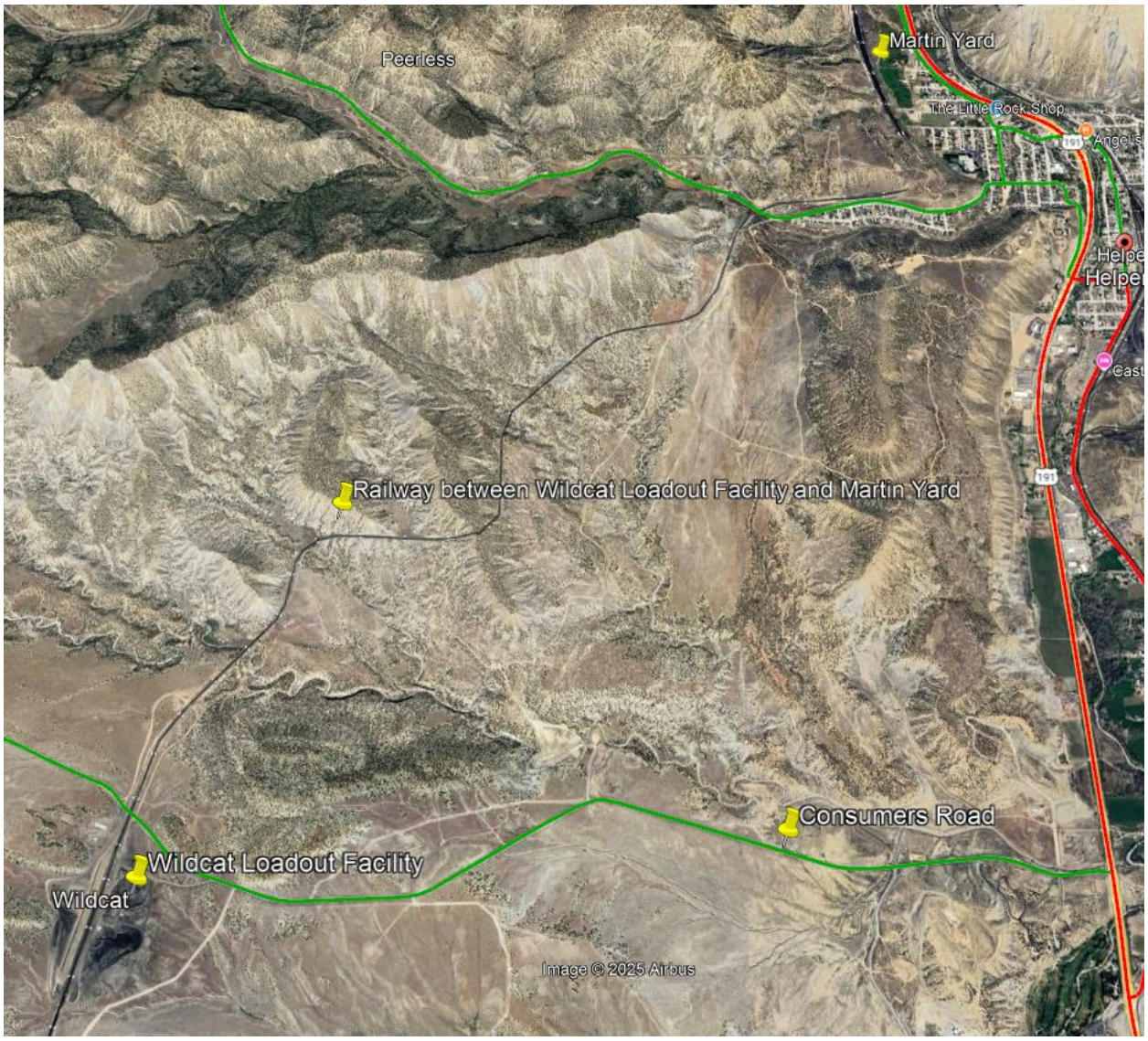
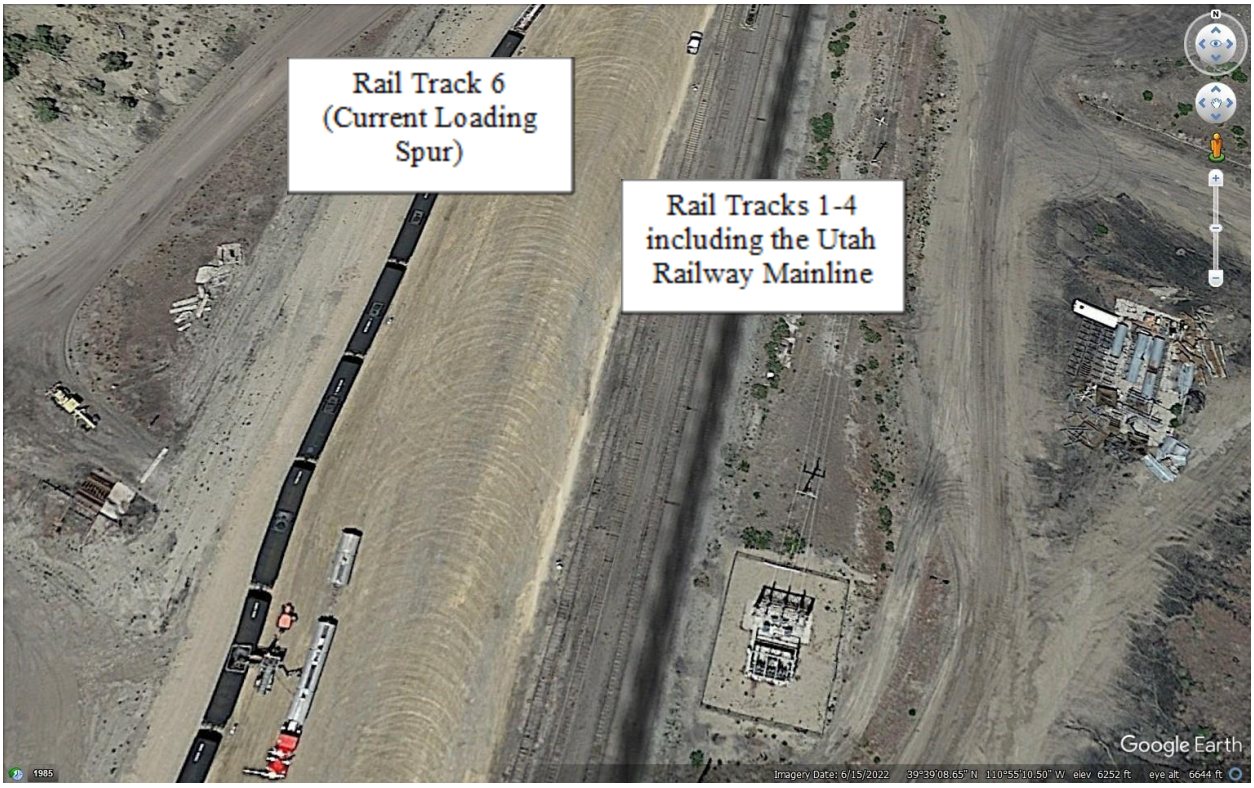


Figure 2-2: Existing Wildcat Loadout Facility Site Layout



Figure 2-33: Existing Wildcat Loadout Facility Site Layout



2.1.1.1. Transloading

The Wildcat Loadout existing facilities for transloading the crude oil from the oil tanker truck to the railway car are described in section 2.1.1.4.

2.1.1.2. Oil Tanker Trucks

CEG2's contractors make approximately 77 oil tanker truck deliveries of crude oil per day to the ROW site. CEG2 estimates that a single oil tanker truck makes two (2) to three (3) deliveries per day. This means there are between 26 and 38 physical oil tanker trucks on the road or an average of 32 oil tanker trucks over a 24-hour period.

2.1.1.3. Truck Ingress and Egress

Oil tanker trucks enter the Wildcat Loadout Facility from Consumers Road (see Figure 2-1) through an existing access road on the west side of the rail tracks. Once on site, trucks proceed southwest to the mobile pumping stations. The empty trucks U-turn and exit the facility on the same access road. Figure 2-2 is a Google Earth aerial photograph of trucks accessing and leaving the facility.

2.1.1.4. Oil Tanker Truck to Railway Car Transloading Facilities

CEG2 has six (6) mobile pumping stations on the west side of the property, which allows up to six (6) oil tanker trucks to unload simultaneously, and directly into the railway cars through a closed system. Figure 2-3 is a Google Earth aerial photograph of a truck transloading onto a railway car. Each mobile pumping station is equipped with a 20 Horsepower, 355 gallons-per-minute fixed pump to transfer the crude oil to the railway cars via hoses connected to the oil tanker trucks. A single truck can unload in approximately sixty (60) minutes including hook up and disconnection of transfer hoses.

2.1.1.5. Vapor Balancing

Emission capture technology at the Wildcat Loadout Facility includes the use of vapor-balance when loading railway cars from the oil tanker trucks. As oil from the oil tanker truck fills the railway car, the vapor in the railway car is displaced by the oil and is returned via a hose to the oil tanker truck. The vapors in the oil tanker truck usually condense back to liquids during the oil tanker truck's return trip, which then mixes in with the next oil load. Any remaining vapors can be combusted at a vapor combustion unit at the well site while the crude oil is transferred into the oil tanker truck.

2.1.1.6. Railway Cars and Oil Trains

At the Wildcat Loadout Facility approximately thirty-five (35) loaded railway cars are assembled into a unit containing approximately 20,000 barrels per day (bbl) of crude oil, then one or more locomotives pull the unit to the Martin Yard. At the Martin Yard, three units are assembled to form one oil train (104 railway cars) for shipment, which is the largest oil train that can be shipped on the rail routes.

Currently the Wildcat Loadout Facility forms one train approximately every three (3) days (up to one (1) unit per day containing approximately 20,000 bbls). The Martin Yard can hold two (2) fully assembled, loaded oil trains with additional space for other railway cars if needed. Utah Railway contracts locomotives from the Union Pacific or the Burlington Northern Santa Fe railroad to remove the oil trains from the Martin Yard.

Locomotive(s) moving loaded railway cars from the Wildcat Loadout Facility to the Martin Yard also deliver empty railway cars to the Wildcat Loadout Facility from the Martin Yard. Empty railway cars for the Wildcat Loadout Facility are stored between approximately milepost 6 and milepost 9 on the Utah Railway mainline. They are separated at any at-grade road-crossings and at other locations to allow wildlife and grazing livestock ingress and egress across the tracks. Road crossings may be temporarily blocked during the movement of railway car units but typically the blockage lasts less than ten (10) minutes.

2.1.1.7. Rail Siding

CEG2 currently leases rail tracks from Utah Railway from milepost 0.25 (1/4 mile from the Utah/Union Pacific Junction) to milepost 9 (Gordon Creek Bridge) on the Utah Railway mainline and the associated ancillary tracks located at the Martin Yard. Rail Tracks #1 through

#4 sit within the Utah Railway ROW UTUT106155575 (Legacy Number UTSL-0-015794). Rail Track #65 sits within CEG2's Wildcat Loadout Facility ROW UTUT106262560. Figure 2-3 is a Google Earth aerial photograph with an overlay of the rail tracks labels. The rail tracks are as follows:
Rail Track #2 is the Mainline.
Rail Track #1 connects to the Utah Mainline (Rail Track #2) beyond the north and south limits of the CEG2's Wildcat Loadout Facility ROW UTUT106262560.
Rail Track #3 is a short spur that connects to Rail Tracks #1 and #4.
Rail Track #4 is currently utilized for railway car loading and connects to Rail Track #2 on the north and south ends of the property.
Rail Track #6 is a current loading rail track within CEG2's Wildcat Loadout Facility ROW UTUT106262560 and connects to Rail Track #1.

2.1.1.8. Other Facilities and Operations

Other facilities in place for transloading the crude oil from the oil tanker trucks to the railway cars are described in the following sections.

Existing Equipment Storage and Office Space

Overlapping CEG2's 270-acre Wildcat Loadout Facility ROW UTUT106262560 is a second CEG2 ROW of 20-acres, UTUT106235040 (Legacy Number UTU-94122). Within ROW UTUT106235040, there is the existing vacant building that served as the mine office with attached garage and a separate garage that was used for storage and for a non-potable water system for the mine office. CEG2 utilizes a single trailer as office space and the existing building as storage for supplies and portable equipment.

Existing Substation

The existing substation consists of a Westinghouse 2,500 KVA (kilo volt-amperes), 46,000 V (volt) to 4,160 V transformer, and capacitors for power factor correction. The substation complies with Rocky Mountain Power and Mine Safety and Health Administration (MSHA) requirements since it was historically used for coal activities.

2.2. Alternative B – Proposed Action

Under the Proposed Action, the BLM would approve the ROW amendment and CEG2 would change the Wildcat Loadout Facility site layout and facilities. Approval of the ROW amendment would enable CEG2 to achieve its currently authorized (under a State permit) throughput of crude oil. The operations would continue 24 hours a day, seven days a week. As part of the ROW amendment the BLM would approve an extension of the ROW grant to December 31, 2044, which is ten years past the current expiration date. If BLM approves the application, CEG2 will construct additional rail siding and storage on the adjacent 51.61-acre TLA parcel (see section 3.2.1).

[5] *There is not a Rail Track #5.*

2.2.1. Wildcat Loadout Description

Figure 2-4 shows the ROW Amendment working area within the boundary of ROW UTUT106262560. Figure 2-5 shows the proposed layout of the ROW Amendment. The operations would be conducted on up to 30 acres of already disturbed lands within the existing 270-acre ROW.

CEG2 estimates the project life to exceed 20 years beyond the present.

CEG2 estimates that approximately forty-five (45) full time employees (13 more than are currently employed at the facility) would be required for full scale operations. Many ancillary jobs (for example, roughly 100 additional oil tanker truck contractors) would also be created consistent with the expansion of operations.

Figure 2-4: Proposed Wildcat Loadout Facility Site Layout

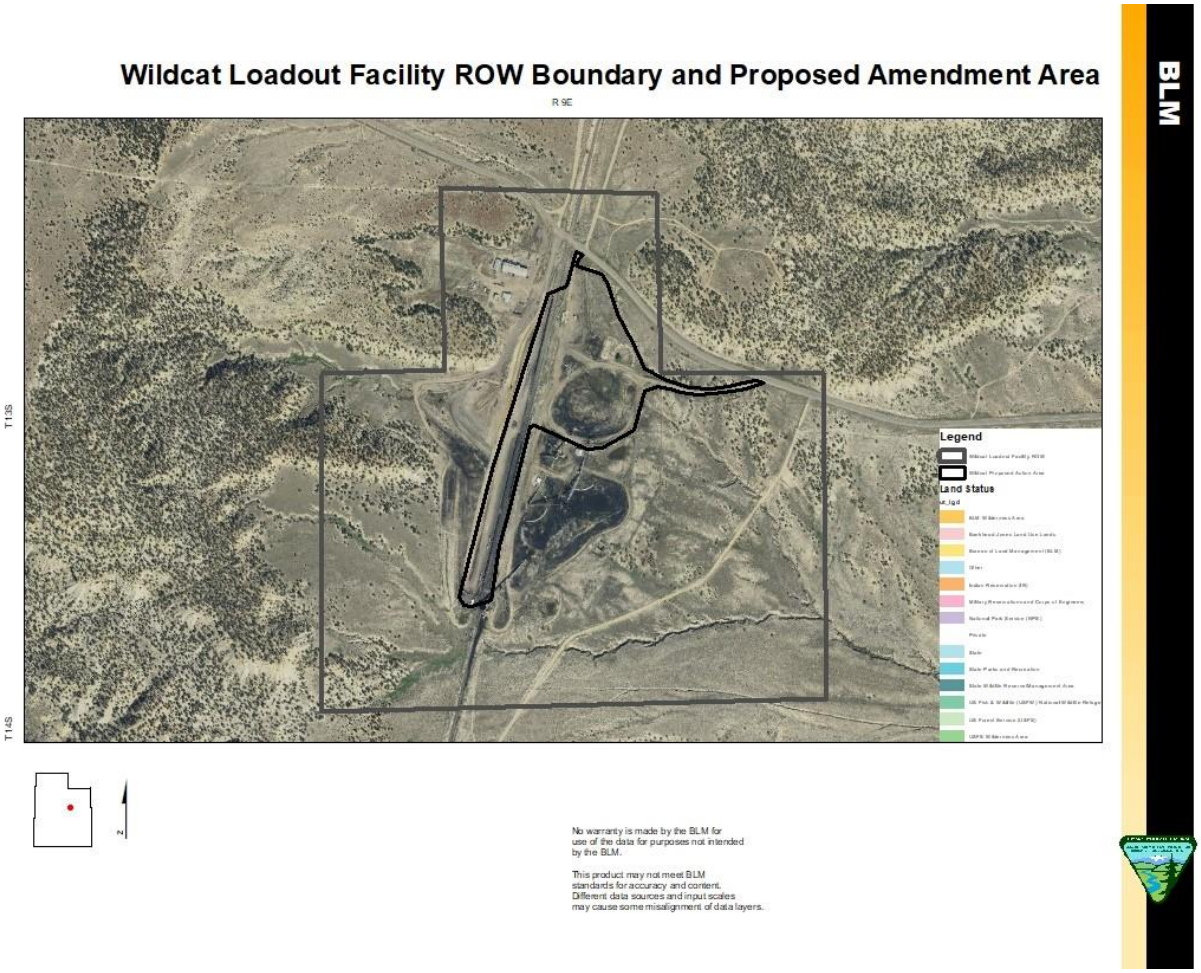
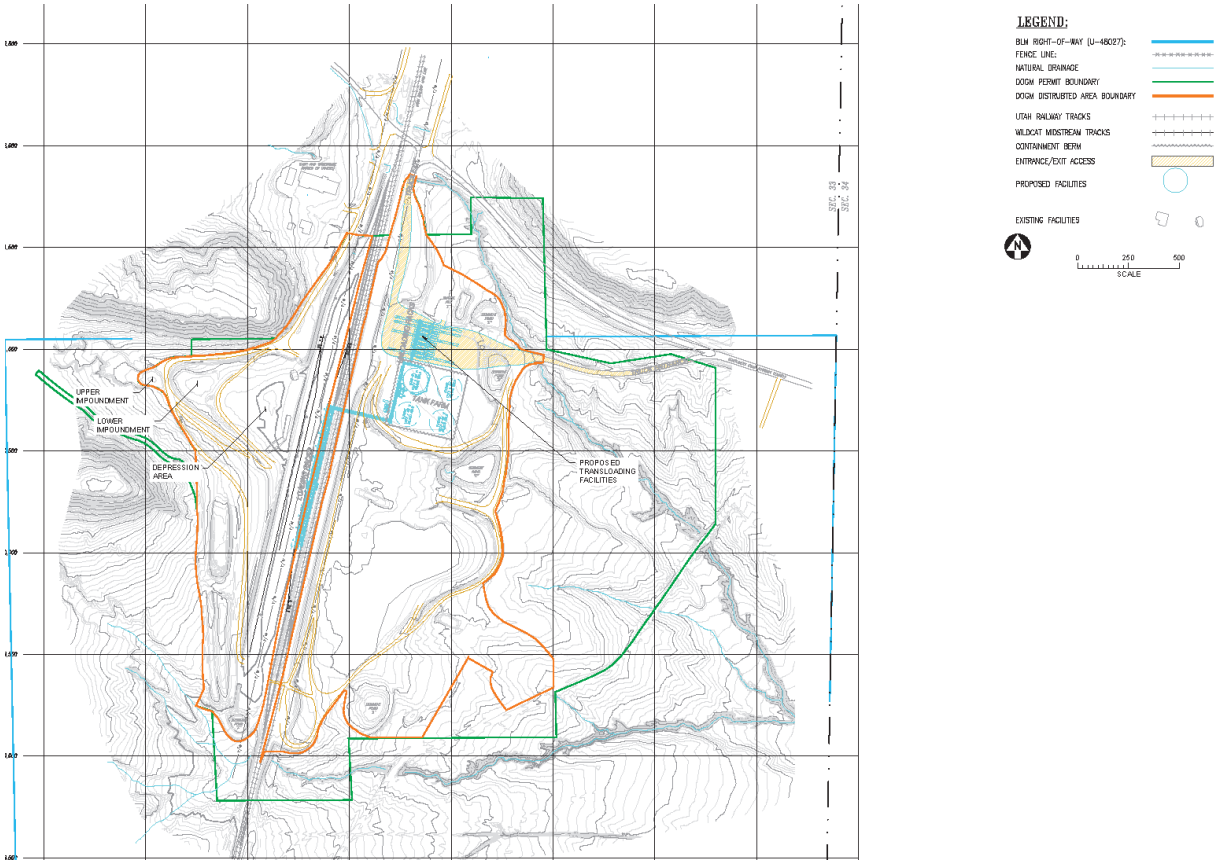


Figure 2-5: Proposed Wildcat Loadout Facility Site Layout



2.2.1.1. Site Grading and Modification

To accomplish the Proposed Action, CEG2 would need to prepare the previously disturbed existing site for the new facilities. CEG2 proposes to:

- Regrade the surface facilities on the east side of the Utah Railway rail track to accommodate vehicle traffic, petroleum storage, promote drainage, and reduce erosion.
- Maintain the road at a maximum grade of 3.5%.
- Make the loadout truck bays flat with a cross-sectional slope of 1% to ensure proper surface water drainage off this area and into a sedimentation pond prior to being discharged off-site.
- Regrade the existing entrance road east of the drainage crossing.
- Install a secondary containment area designed to accommodate two 80,000-barrel (120’ diameter x 48’ tall) petroleum storage tanks. Containment will be achieved by mechanical compaction of the soils to a 98% proctor. A valved culvert would provide controlled discharge of collected storm water within the secondary containment into the sediment pond.

The regraded existing entrance road access into the loadout truck bays would require filling in the north side of one of the sediment ponds. However, the south end would be extended to retain the runoff volume characteristics required for the drainage area reporting to this pond. Although

the pond includes an approved Utah Pollutant Discharge Elimination System (UPDES) discharge, the point source would not be relocated by this modification. One culvert would be removed to accommodate the area required for the turning radius of the tanker trucks exiting the loadout truck bays. The new culvert would extend east. Drainage ditches have been designed to collect runoff from areas on the northeast end of the facility and divert storm water runoff into a sediment pond. One Topsoil Pile is planned to be moved to another site within the ROW but outside the proposed facility area.

2.2.1.2. Unloading Facilities

The facilities required for unloading the crude oil from the oil tanker trucks into the tank farm are described in Section 2.1.6 through 2.1.10. The maximum unloading capacity is designed to be greater than the currently State-permitted maximum throughput to eliminate the risk of oil tanker truck backup onto Consumers Road.

2.2.1.3. Oil Tanker Trucks

CEG2 proposes to add approximately 268 oil tanker truck deliveries per day to the current 77 truck deliveries, totaling approximately 345 truck deliveries per day. CEG2 estimates that a single oil tanker truck makes two (2) to three (3) deliveries per day. At maximum throughput capacity, CEG2 estimates this would place between 115 and 172 physical oil tanker trucks on the road or an average of 143 oil tanker trucks over a 24-hour period.

2.2.1.4. Truck Ingress and Egress

Oil tanker trucks would enter the Wildcat Loadout Facility from Consumers Road through an existing access road on the northeast side of the facility. Once on site, trucks would proceed west to a multiple lane truck unloading station. For safety reasons, the empty trucks would then exit the facility using a second existing access road adjacent to the rails on the northeast side of the facility (the coal loadout road).

2.2.1.5. Oil Tanker Truck Unloading Racks

CEG2 proposes to install ten (10) truck unloading lanes on the east side of the property where a coal storage area was previously located. The proposed setup would allow up to ten (10) oil tanker trucks to unload simultaneously.

Each unloading lane would be equipped with a 50 Horsepower, 555 gallons-per-minute fixed electric pump to transfer the crude oil to the storage tanks via hoses connected to the oil tanker trucks. CEG2 estimates this equipment would allow a single truck to be unloaded in approximately twenty-two (22) minutes, with a total discharge time of approximately thirty (30) minutes including hook up and disconnection of transfer hoses. With a total of ten (10) unloading lanes this would allow a total of twenty (20) oil tanker trucks per hour to be processed through the facility, leading to a total of approximately 345 oil tanker trucks per day. CEG2 estimates that on average, six (6) or seven (7) oil tanker truck deliveries would be made per half hour.

Oil tanker trucks at the unloading stations would be emptied into the storage tanks through a closed system of carbon steel piping and fixed pumps. All pipes, valves, and fittings from the pumps to the storage tanks would have either electrical heat tracing cables or stainless-steel tubing for the circulation of thermal transfer fluid. All pipes, valves and fittings would be insulated with two inches (2") of fiberglass insulation clad in BLM-approved environmental color Covert Green aluminum sheeting to protect the insulation from weather. The carbon steel piping would be of various sizes to accommodate the maximum flow of product.

2.2.1.6. Oil Tanker Truck Staging

CEG2 estimates that the facility on the east side of the property, east of the unloading bays, contains room for staging approximately twenty (20) oil tanker trucks for a maximum of thirty (30) oil tanker trucks onsite (including the 10 in the loading racks). In addition, if the east side staging becomes backed up, additional staging of oil tanker trucks could be performed on the west side of the property to maintain clear passage of Consumers Road. There is an existing turning basin on the west side of the property that allows the trucks on the west side to turn into the facility.

2.2.1.7. Tank Farm Facilities

Construction would include two (2) permanent internal floating roof carbon steel storage tanks. The two oil storage tanks would have a calculated shell capacity of approximately 88,748 bbls each with a maximum working capacity of approximately 80,000 bbls each. They would store oil until it can be loaded onto a rail car. The diameter of the tanks would be approximately 120 feet and a height of 48 feet. Each tank would be outfitted with a mechanical shoe for vapor release prevention.

The oil in the tanks would be heated with two-inch diameter serpentine heating coil bundles inside the tank. The heat transfer fluid inside the coils would be heated by a natural gas fired hot oil heater. Compressed natural gas would be trucked into the Wildcat Loadout Facility in mobile storage tanks from a supplier and tanks interchanged based on demand.

The tank(s) would be outfitted with an internal electronic level gauge with an external display and an external mechanical gauge board as a primary and secondary means of monitoring the levels in the tank. The primary gauge would be utilized as a High-Level warning device with a warning light and external audible alarm. A secondary and independent High-High Level warning device would be installed with a warning light and external audible alarm.

Individual tank foundations would be designed in accordance with the American Petroleum Institute (API) Standard 650 utilizing geotechnical reports for the soil conditions at the site. The standards include concrete footings, ring wall foundations, tank foundation fill materials, and leak detection. Each tank foundation would also include the installation of cathodic protection to protect the tank floor from corrosion.

The tank construction would be completed on site. Excavation and grading activities would be performed with equipment appropriate for the task, including, but not limited to, track-hoes, back-hoes, graders, and dozers. Tanks would be installed using an appropriately sized crane and other lifting equipment as necessary, portable welding equipment, and scaffolding. The tanks would be insulated using four inches of insulation and clad in a Covert Green-colored aluminum sheeting on the shell and roof to protect the insulation from weather.

Earthen berms, meeting the requirements of 40 CFR 112.7 and National Fire Protection Association 30, 22.11.2.6, would be constructed around the tanks to ensure adequate capacity to capture the content of the single largest tank minus the footprint of other tanks within a diked area, plus sufficient allowance for freeboard to accommodate 10% precipitation or the equivalent of a 24-hour, 25-year storm event. Vehicle access would be provided to the diked area for emergency response, maintenance, and other activities.

2.2.1.8. Loading Facilities

The facilities required for loading the crude oil from the tank farm to the railway cars are described in the following sections (2.1.12 through 2.1.18). Note that the maximum loading capacity is greater than the currently permitted maximum throughput capacity to eliminate the risk of oil tanker truck backup onto Consumers Road.

2.2.1.9. Railway Car Unloading Racks

Twelve (12) dual-sided railway car loading racks (24 total railway car loading spots) would be constructed adjacent to the rail tracks and would be connected to the tanks by carbon steel pipes, valves, and fittings to accommodate maximum flow to the railway cars. All pipes, valves, and fittings would be traced with either electrical heat tracing cables or stainless-steel tubing for the circulation of thermal transfer fluid, insulated with two inches (2") of fiberglass insulation clad in a Covert Green-colored aluminum sheeting to protect the insulation from weather, and installed aboveground.

There would be three (3) 150 Horsepower, 2,000 gallon per minute electric pumps installed for the loading of railway cars. Three pumps would be utilized during the loading process to achieve a maximum flow rate of 6,000 gallons per minute to the 12 loading racks or a maximum of 250 gallons per minute to each loading spot. A fourth pump (150 Horsepower, 2,000 gallon per minute) would be utilized as a "Hot Spare" for when individual pumps are taken out of service for maintenance or repairs. The maximum loading rate per rail loading spot meets the requirements set forth by the National Fire Protection Association Technical Committee on Static Electricity.

2.2.1.10. Vapor Combustion Unit

An enclosed vapor combustion unit would be installed on the east side of the property to combust any vapors generated during the railway car loading process as required by the Utah Department of Air Quality, Approval Order DAQE-AN150710004-24. The combustion chamber would be approximately 96 inches in diameter and the vertical stack would be approximately 40

feet high. The vapor combustion unit would be smokeless, forced draft, and air and gas assisted. The pilot gas and assist gas would be compressed natural gas. The vapor combustion unit is designed to combust the vapors at a maximum crude oil flow rate of 6,000 gallons per minute to match the maximum liquid loading rate.

Vapor hoses with detonation arrestors would be connected to each railway car during the loading process. Vapors would be routed to a common header from each railway car to the combustion unit. Drip legs and knock-out pots would be located along the common header to remove any liquids. Liquids would be pumped to the loading racks for reentry into the product stream.

2.2.1.11. Railway Cars and Oil Trains

At the Wildcat Loadout Facility approximately thirty-five (35) loaded railway cars are assembled into a unit containing approximately 20,000 bbl of crude oil, then one or more locomotives pull the unit to the Martin Yard. At the Martin yard, three units are assembled to form one oil train (104 railway cars) for shipment, which is the largest oil train that can be shipped on the rail routes.

Under the Proposed Action, the Wildcat Loadout Facility would load 1.7 trains every day (up to five (5) units per day containing approximately 100,000 bbls). The Martin Yard can hold two (2) fully assembled, loaded oil trains with additional space for other railway cars if needed. Utah Railway contracts locomotives from the Union Pacific or the Burlington Northern Santa Fe railroads to remove the oil trains from the Martin Yard.

Locomotive(s) moving loaded railway cars from the Wildcat Loadout Facility to the Martin Yard also deliver empty railway cars to the Wildcat Loadout Facility from the Martin Yard. Empty railway cars for the Wildcat Loadout Facility are stored between approximately milepost 6 and milepost 9 on the Utah Railway mainline. They are separated at any at-grade road-crossings and at other locations to allow wildlife and grazing livestock access across the tracks. At-grade road-crossings may be temporarily blocked during the movement of railway cars but typically the blockage lasts less than ten (10) minutes.

2.2.1.12. Rail Siding

CEG2 currently leases tracks from Utah Railway from milepost 0.25 (1/4 mile from the Utah/ Union Pacific Junction) to milepost 9 (Gordon Creek Bridge) on the Utah Railway mainline and the associated ancillary tracks located at the Martin Yard. Up to three additional rail tracks would be constructed west of Rail Tracks 1-4, including the Utah Railway mainline, and east of Rail Track 6, the current loading spur (see Figure 2-4). The rail tracks would be up to 2,200 feet in length and would be installed outside of the Utah Railway ROW but within the CEG2's ROW UTUT106262560.

2.2.1.13. Other Facilities and Operations

Other facilities required for loading the crude oil from the oil tanker trucks to the tank farm to the railway cars are described in the following sections.

Motor Control Center

A forty (40) foot long by eight (8) foot wide Motor Control Center and pad mounted transformer(s) would be installed on the east side of the property within the current disturbed area. The Motor Control Center would be the primary feed for all electrical equipment installed as part of this project.

Facility Lighting

All new facility lighting would be cast downward. New facility lights would be installed as follows:
Truck unloading lanes lighting would be mounted to the overhead piping structures.
Rail loading racks lighting would be mounted over each loading station and the underside of the rack structure for operators to monitor outlet valves on the underside of the railway cars.
Tank lighting would be mounted to the railing structure approximately eight (8) feet above the top of the tank over the landing platform.
Product transfer pumps lighting would be mounted to the piping structures.
Vapor combustion unit lighting would be mounted to the piping structure.

Reclamation

The ROW holder for the Wildcat Loadout Facility would be responsible for reclaiming the facility according to the Utah Division of Oil, Gas, and Mining (UDOGM) Mining and Reclamation Plan (MRP) and the BLM Green River District Reclamation Guidelines.

Reclamation would begin after operations have ceased. All equipment and facilities would be dismantled and demolished or salvaged. Salvaged equipment would be sold or removed. All concrete would be demolished and crushed into 12" minus material, rebar would be removed as much as possible and the inert material buried on-site.

On the west side of the tracks, it is impossible to restore the natural drainage pattern of the unnamed drainage because this system intercepts the Utah Railway track embankment. This embankment is managed by Utah Railway and will not be reclaimed, and the water impoundment structures adjacent to Utah Railway’s track would be left in place.

On the east side of the tracks, the area would be contoured to approximate the pre-disturbance topography. The topsoil would be spread over the recontoured area, then would then be gouged with rippers or pockmarked. The area would be seeded with the certified weed-free seed mix shown in Table 2-1, or by an adjusted mix approved by the BLM authorized officer using hand broadcast, hydroseeding, hydro mulching, or other approved methods.

Monitoring would be conducted according to the UDOGM MRP and/or according to the Green River District Reclamation Guidelines to ensure successful establishment of native plant species. A reference area has been established near the southeastern corner of the ROW and would be used for comparison of vegetation cover. CEG2 would follow UDOGM or BLM recommendations for further seeding, soil supplements, or other corrective measures during the any of the monitoring years. While UDOGM is the regulatory authority of the site, the operator

will be required to comply with Surface Mining Control and Reclamation Act (SMCRA) and the Utah Coal Regulations. As part of these regulations, the success of revegetation of the disturbed area will be judged on the effectiveness of the vegetation for the approved post mining land use (PMLU) and as dictated by R645-301-356. The approved PMLU for the Wildcat Loadout Facility is grazing and wildlife. A period of extended responsibility for successful establishment of vegetation will begin after the last year of augmented seeding. Vegetation parameters identified for the PMLU will equal or exceed the approved success standards during the growing seasons of the last two years of extended responsibility period. The extended responsibility period is 10 years and monitoring of the vegetation is required at specific schedules. The reclamation will be deemed successful by UDOGM when the approved success standards are met. Once the standards have been achieved, the operator may be released from responsibility and all surety bonds will be released.

Table 2-1: Reclamation Seed Mix

Scientific Name	Common Name	PLS/Acre
Amelanchier utahensis	Utah Serviceberry	2 to 3
Artemisia tridentata	Big Sagebrush	0.06
Krascheninnikovia lanata	Winterfat	2.00
Purshia tridentata	Bitterbrush	Up to 6.00
Achillea millefolium	Yarrow	0.05
Linum lewisii	Lewis Flax	1.00
Penstemon palmeri	Palmer Penstemon	0.50
Heliomeris multiflora	Showy Goldeneye	0.2
Bouteloua gracilis	Blue Grama	0.60
Pseudoroegneria spicata	Bluebunch Wheatgrass	2.50
Elymus trachycaulus	Slender Wheatgrass	2.50
Pleuraphis jamesii	Galleta	2.50
Hesperostipa comata	Needle and Thread Grass	3.00
Achnatherum hymenoides	Indian Ricegrass	2.0
	Total	21.21 to 27.21

2.2.2. Design Features

The following design features are included in the Proposed Action to avoid or minimize impacts.

2.2.2.1. Dust Control

During construction, dust control would be conducted, as necessary, utilizing water on the construction surfaces and/or roadways. Under normal operations, unpaved haul road areas would be treated with Magnesium Chloride to manage fugitive dust emissions. Also, vehicle speeds would be restricted to reduce fugitive dust. Finally, CEG2 would abide by all applicable requirements for emission standards listed in Utah Administrative Code R307-205.

2.2.2.2. Noise

No new noise levels are anticipated above current operating level. The largest electric motor being installed would be 150 Horsepower. The motors would be of a Totally Enclosed Fan

Cooled (TEFC) design and meet the decibel (dBA) requirements of National Electrical Manufacturers Association (NEMA) Standard Motor and Generator (MG)-1. All equipment as required meets Class I, Division 2 requirements for intrinsically safe equipment.

It is anticipated based on equipment design standards that all noise levels would be less than or equal to 85 dBA at three (3) feet. Based on 85 dBA at three (3) feet, the sound pressure would be reduced to 60.1 dBA at fifty-three (53) feet, which is at a level of normal conversation.

At the completion of construction and when operations begin, per Occupational Safety and Health Administration (OSHA) Standard 1910.95 Occupational Noise Exposure, all equipment would be tested for compliance with this standard and engineering controls would be put in place to reduce any noise levels that do not meet the standard.

2.2.2.3. Visual Resources

Down shielded or direct lighting must be used unless otherwise required for safety. Make the facilities the BLM-approved Cover Green color to match surrounding environment and minimize potential color contrast unless otherwise required for safety.

2.2.2.4. Spill Prevention, Control, and Countermeasures (SPCC)

CEG2 would be responsible for taking reasonable precautions to avoid spills. The current Spill Prevention Control and Countermeasure Plan (SPCC plan) would be followed to protect the undisturbed areas form accidental spills. The plan is available for review at the Wildcat Loadout Facility. Construction workers and employees of the operation are instructed on the information in the SPCC plan. In the event of a spill or release of petroleum, procedures outlined in the SPCC Plan would be followed. Emergency spill containment supply kits would be stored on site.

Tanks would be maintained and managed in a manner according to American Petroleum Institute (API) Recommended Practice (RP) 653 that would prevent leakage and provide applicable safety measures. If product is present in a transfer hose, the product would be captured in a metal bucket and emptied into a recycle container to cycle back into the product stream.

In the event of a spill, the incident would be reported in accordance with any federal, state, and/or local guidelines and the necessary repairs would be made as quickly as possible.

Truckers would be trained on proper loading and unloading safety procedures of the product. Railway cars would be inspected before loading operations begin and drip pans would be used during the filling operation to prevent product from reaching the ground.

2.2.2.5. Air Quality Permits

The Proposed Action would be subject to state standards for air quality, including the requirement for New Source Review in Utah R307-401 and Approval Order DAQE-AN150710004-24. This 2024 Approval Order sets the maximum throughput allowed at the facility.

2.2.2.6. Water Diversion Around Facility

Runoff from the undisturbed areas is routed around the disturbed areas via natural drainages, diversion ditches, and culverts into a series of sediment ponds to prevent runoff from flowing into the facility area. Precipitation that falls onto the disturbed areas flows into disturbed drainage diversion ditches and routes to sediment ponds. Under the Proposed Action, runoff flows will be directed to existing sediment ponds.

2.2.2.7. Stormwater Management

A Storm Water Pollution Prevention Plan (as required by the site's UPDES permit) is currently developed and is utilized for all day-to-day operations. For construction of the purposed facilities, a construction Storm Water Pollution Prevention Plan would be developed (if needed) to cover any pollution prevention strategies not covered in the existing plan.

All precipitation that falls onto the disturbed area of the Wildcat Loadout Facility would flow into diversion ditches and route to sedimentation ponds. Diversion ditches are designed to carry the capacity of a 10-year/6-hour storm event. Sedimentation ponds are designed to handle and treat the capacity of a 10-year/24-hour storm event. If a major storm fills the ponds, any necessary decant or discharge would comply with the facility's UPDES permit.

2.2.2.8. Weed Control

Periodic inspection for noxious and invasive weeds would occur. If noxious or invasive weeds are found, CEG2 would use herbicide or mechanical treatments (such as clipping seed heads or digging roots) as appropriate to remove the weeds. If herbicides are used, CEG2 would submit a Pesticide Use Proposal to the BLM for approval, any herbicides would be approved by the BLM and applied by a licensed applicator.

All construction vehicles and equipment would be power washed prior to being transported onsite to remove weed seed and propagules.

2.2.2.9. Wildlife (Migratory birds, raptors, and Greater sage-grouse)

Anti-perching devices would be installed on facilities and covering/sealing of all vertical pipes/holes of less than 12" in diameter would occur, to minimize entrapment and entanglement following best practices outlined by the U.S. Fish & Wildlife Service.

Potential nesting surfaces where bird use of structures is likely to cause take (e.g., electric poles where fire/electrocution is possible) would be monitored by CEG2 at least once every three days for any nesting activity from April 15th-August 1st. If birds have started to build any nests, the nests would be removed before they are completed, unless the nest is protected by federal, state, or local regulations.

2.2.2.10. Site Analysis

CEG2 has completed a geotechnical analysis and soils analysis.

2.3. Alternatives Considered but Eliminated from Detailed Analysis

The following alternatives were considered but dismissed from detailed analysis for the reasons described below.

2.3.1.1. Dismissed Alternative 1: CEG2 Oil Tanker Traffic in Gate Canyon

During public scoping in 2023 (see section 4.1), the public requested that CEG2's contractors not use Gate Canyon to haul crude oil from the Uinta Basin to the Wildcat Loadout Facility. Further, they were concerned that Duchesne County's pursuit of funding to pave Gate Canyon road was a connected action to the Wildcat Loadout Facility ROW amendment.

Under this alternative, oil tanker traffic would access the Wildcat Facility by driving on Wells Draw Road, Gate Canyon Road, Nine Mile Canyon Scenic Backway, and Highway 6 from its intersection with Nine Mile Canyon Scenic Backway to Consumers Road. This alternative was dismissed from detailed analysis for the following reasons.

First, the BLM determined that restricting use of an existing road is outside the BLM's jurisdiction because transportation by tanker truck is regulated by Department of Transportation (oil tanker trucks) and the Pipeline and Hazardous Materials Safety Administration (hazardous materials). (see Table 1-4).

Second, CEG2 has been working with the Utah Legislature and Department of Transportation to prepare Highways 191 and State Road 6 for the current and foreseeable amount of oil tanker truck traffic[6]. Funding for upgrades to Gate Canyon Road has not been requested by CEG2. Additionally, CEG2's representatives have stated that they do not intend to pursue improvements to Gate Canyon Road.

Third, Gate Canyon in not a connected action because Duchesne County has been independently and intermittently pursuing pavement of Gate Canyon Road since 2011, seven years before CEG2 acquired the Wildcat Facility ROW and fourteen years before BLM received CEG2's current proposed ROW amendment. BLM received an updated application from Duchesne County in February 2022. Duchesne County's stated purpose in their application is to improve recreational access between Duchesne and Carbon counties. Duchesne County's application is not approved and environmental compliance with the NEPA, National Historic Preservation Act (NHPA), Endangered Species Act (ESA) and other applicable laws is likewise not completed. Also, in January 2023, Duchesne County requested funding from the State Legislature for realignment and paving Gate Canyon Road, but the request has since been dropped from Legislative consideration.

2.3.1.2. Dismissed Alternative 2: Transportation Alternatives

During public scoping in 2023 (see section 4.1), the public requested that the oil not be transported along the railway through Eagle County, Colorado. Under this alternative, the oil would be transported along the rail lines shown in Figure 1-3 other than the line that would go

[6] *See https://storymaps.arcgis.com/stories/553c1dcf5bb24a4eb043b8913b125a12*

through Eagle County, Colorado. This alternative was dismissed from detailed analysis for the following reasons.

First, a decision to allow the expansion of the Wildcat Loadout Facility on the part of the BLM would not approve any particular transportation route, so transportation routes (other than Consumers Road and the railway between Wildcat Loadout Facility and the Martin Yard) are out of the scope of the EA as described in section 1.2 and 3.2. See also 3.3 bullets 4 and 5.

Second, train transportation and hazardous materials transportation are regulated by other agencies as described in Section 1.5, so it is outside the jurisdiction of the BLM.

Third, decisions regarding the transportation of crude oil from the lease holdings to market are dictated by market conditions, origination and destination points, and the intended use of the crude oil at the time of production and sale. These are all out of the scope of the EA as described in section 1.2 and 3.2.

CHAPTER 3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

3.1. General Setting

Construction of the Wildcat Loadout Facility was completed in 1985. The coal loading facility on the west side of the ROW has been inactive since 2016, but the equipment is still in place. In 2014, permanent facilities were added to the ROW to allow for oil transloading. Of the 270-acre ROW, approximately 75 acres are previously disturbed by these previous and current operations. The ROW is located just off the main paved Consumers Road, which is a 3.5-mile-long public road maintained by Carbon County. This road was previously used by the coal mine operator for mine access and coal transportation. It is currently used by trucks hauling crude oil, recreationists accessing public lands, and livestock grazing permittees. The ROW is within the Consumers Wash Allotment and is fenced to exclude livestock.

The Wildcat Loadout Facility is located on generally flat ground at an elevation of approximately 6,200 feet. The surrounding vegetation is pinyon-juniper woodland and sagebrush grassland. The ROW was sagebrush grassland before the Wildcat Loadout Facility was constructed. Noxious weeds and invasive weeds found in the ROW and in the area include, but are not limited to tamarisk, musk thistle, cheatgrass and Russian thistle. Animal species found in the area are mostly elk, mule deer and raptors. Since the Wildcat Loadout Facility is already disturbed, it does not contain habitat suitable for any species. The existing heavy truck traffic and train activity also make this an undesired area for most wildlife species. The nearest waters sources are more than 2.5 linear miles to the east of the ROW.

3.2. Scope of Analysis

This chapter presents the potentially affected existing environment (i.e., the physical, biological, social, and economic values and resources) and environmental effects for each issue identified for detailed analysis.

The analysis focuses on the reasonably foreseeable effects of the alternatives that are useful to the decision-making process or that contain information on which the agency can act. Therefore, the analysis focuses on the effects from the redesign, installation, and operation of the Wildcat Facility, the truck traffic on Consumers Road, and the train traffic between the Wildcat Loadout Facility and the Martin Yard.

The analysis does not include upstream effects from the Uinta Basin oil production and oil tanker truck transportation of crude oil from the oil field to the Consumers Road turnoff, or downstream effects from railway car transportation of crude oil from the Martin Yard to the refineries and refining and downstream use of crude oil. The scope and occurrence of those actions do not depend on whether the BLM approves the Wildcat Loadout Facility expansion because the level of upstream crude oil production in the Uinta Basin, the level of train traffic downrail of the Martin Yard, and the level of downstream refining are instead driven by independent market conditions (such as the price of oil) and technological advancements, not the operation of the Wildcat Loadout Facility, BLM does not consider them reasonably foreseeable effects of the BLM’s decision.

Specifically, with respect to upstream production, as documented in Appendix B, as of February 2025, Utah's crude oil production is 182,000 bbls per day. By comparison, Salt Lake City refinery capacity is 80,000 bbls per day, and Carbon County's *existing* transloading capacity is 180,000 bbls per day. Therefore, crude oil export capacity currently exceeds crude oil production for the entire state of Utah. Even if BLM does not approve the Proposed Action, existing export capacity could support increased crude oil production in the Uinta Basin. In other words, a BLM decision to authorize the Wildcat Loadout Facility expansion will not necessarily increase crude oil production in the Uinta Basin (which hinges on overall market forces). Instead, so long as the price of crude oil remains low, production in the Uinta Basin will likely remain static, and expansion of the Wildcat Loadout Facility will likely shift where transloading occurs, by providing a more convenient location to transfer crude oil from trucks to rail cars. In such a scenario, the amount of oil produced in the Uinta Basin does not depend on whether the BLM authorizes the expansion of the Wildcat Loadout Facility.

The situation is similar with respect to train traffic downrail of the Martin Yard and downstream refining. While expansion of the Wildcat Loadout Facility may change how crude oil arrives at the Martin Yard, the ultimate amount of crude oil that leaves the Martin Yard on train cars and is ultimately refined does not hinge on expansion of the facility. That, ultimately, depends on market forces which, in turn, impact crude oil production in the Uinta Basin, both of which are unrelated to the Proposed Action. Moreover, future downstream actions that BLM does not control are beyond the scope of this analysis.

Accordingly, the analysis in this EA is limited to analyzing the effects of those activities that hinge on whether BLM authorizes the Proposed Action and more crude oil is transloaded at the Wildcat Loadout Facility—namely, increased truck traffic on Consumers Road, activities at the expanded Wildcat Loadout Facility, and increased railway traffic between the Wildcat Loadout Facility and the Martin Yard—and does not analyze the effects of those activities, addressed earlier in this section, that do not hinge on BLM's decision.

3.2.1. Analysis Assumptions

The following assumptions influence the scope of analysis and environmental effects.

1. CEG2 indicated that their proposed ROW amendment would accommodate a target throughput of 100,000 bbls per day. Portions of the project are overdesigned to prevent tanker trucks parking on Consumers Road due to backlogs at the offloading facilities. Therefore, the air quality analysis assumes the proposed facilities would accommodate a throughput of approximately 100,000 bbls per day.
2. Under the No Action Alternative, CEG2 would build and use the TLA Lease Transloading Facility to transload oil from the Uinta Basin oil fields to the Gulf Coast refineries and would also continue transloading at the Wildcat facility using current transloading facilities. The same length of Consumer's Road would be used, but tanker truck traffic would continue on approximately one mile of existing dirt road (see Figure 2-1, the west half of the dirt road loop just north of the Wildcat Loadout Facility) to access the facilities at the TLA lease.
3. If BLM approves the Wildcat modifications, CEG2 will build and use their TLA property to accommodate additional train storage and rail siding, but they would not install the Proposed Action's transloading facilities on it.

4. The Wildcat Loadout Facility would not increase total crude oil hauling traffic in Uintah and Duchesne Counties because oil production is occurring regardless of this transloading expansion and will be taken to a refinery outside of these counties either by truck or transloading onto a train through a different loadout facility, regardless of the alternative selected (see section 3.2).
5. The Proposed Action would re-allocate oil tanker truck traffic to the Wildcat Loadout Facility from other transloading facilities within Carbon County which are located more than 16 miles away in the Wellington, Utah area or the Salt Lake City refineries.

3.3. Reasonably Foreseeable Future Actions (RFFA) Common to all Issues

The following past, present, and reasonably foreseeable actions were considered during preparation of the cumulative impacts analysis.

- ConocoPhilips Company/Scout Energy Group/XTO Energy UTUT105525661 (legacy number UTU 079159) Oil and Gas Lease
- CEG2's existing ROW UTUT106262560 known as the Wildcat Loadout Facility as described in the no action alternative and overlapping CEG2's existing ROW UTUT106235040 for additional facilities.
- Utah Railway's ROW UTUT106155575, railway and sidings that connect the Wildcat Loadout Facility with the Martin Yard in Helper, Utah.
- PacifiCorp doing business as Utah Power and Light UTUT106092525 (legacy number UTU-94607) 48-kV powerline, and UTUT106103913 (Legacy Number UTU-53815) switch rack.
- Emery Telcom UTUT105987487 (legal number UTU-32293) buried communication line.
- Carbon County UTUT106099056 (Legacy Number UTU-54688) Consumer Road.
- Carbon County UTUT106107053 (Legacy Number UTU-52810) Access Road
- Carbon County UTUT105884090 (Legacy Number UTU-87938) Geezer Backbone Trail
- CEG2's existing ROW UTUT106262560 for coal loading and crushing activities up to 5.5. million tons per year.
- Natural Resources Conservation Service's Upper Price River Watershed Plan and Environmental Impact Statement, one alternative of which affects the alignment of Consumers Road.
- Livestock Grazing in the Consumers Wash allotment within the analysis area.

3.3.1. Leased TLA Land Development

Under the No Action Alternative, CEG2 would create loadout facilities onto 51.61 acres of adjacent leased TLA lands to add 80,000 bbls/day transloading capacity to their current Wildcat Loadout Facility operation. The development that would occur on the TLA parcel would require the same facilities (tanks, truck unloading racks, tanks, vapor combustion unit, rail loading facilities, motor control center, etc.) described under Alternative B: Proposed Action.
Under the Proposed Action Alternative, CEG2 would use their TLA lease for rail storage and rail siding to assemble trains.

3.4. Issue 1: What impacts would occur because of the increase in Consumers Road truck traffic?

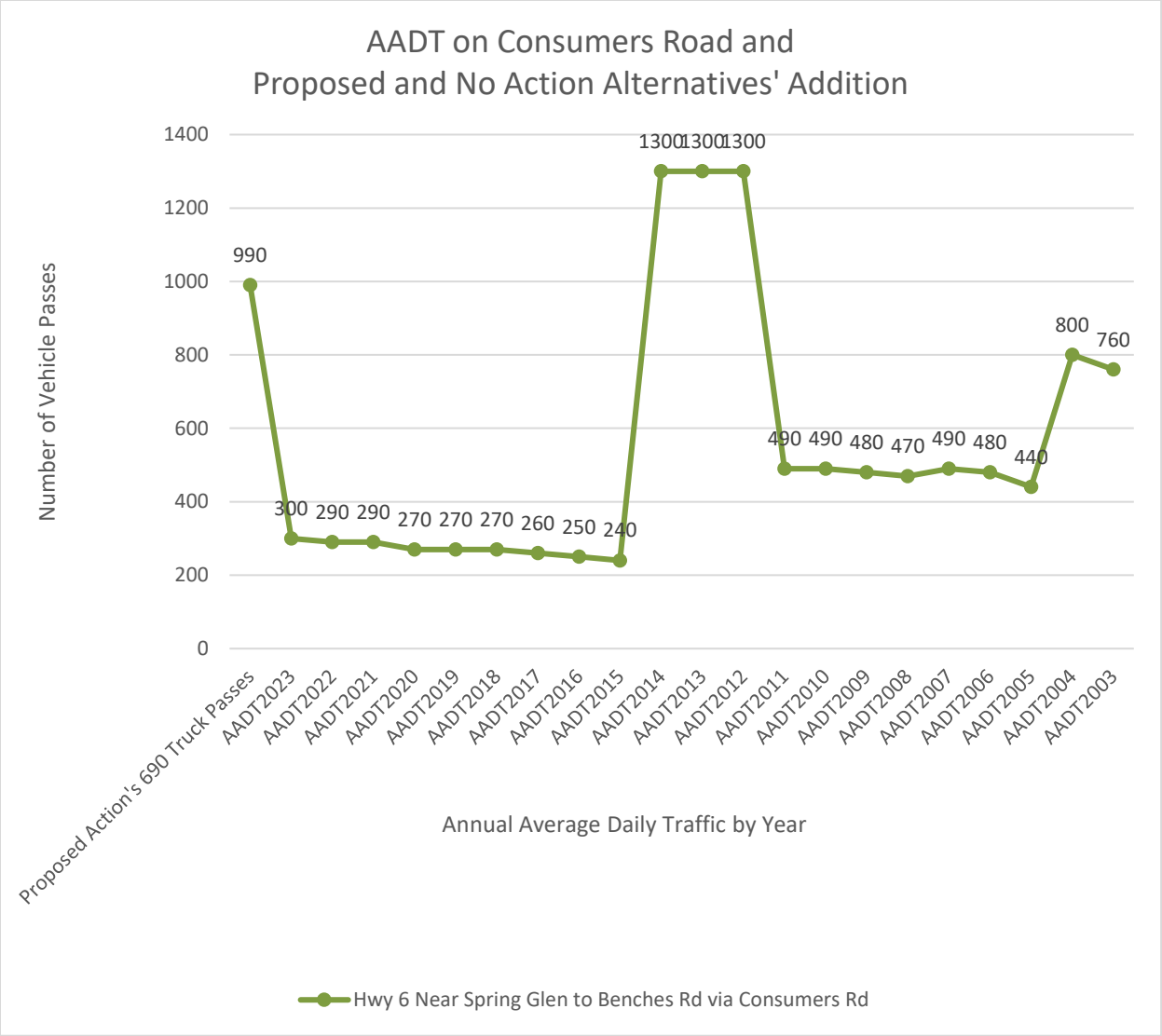
3.4.1. Affected Environment

The Wildcat Loadout Facility has been used as a coal loadout for the railway since the 1920s. It is accessed by 3.5 miles of a paved[7], two-lane, county-maintained road called Consumers Road (see Figure 2-1). Approximately 2 miles are within Greater sage-grouse General Habitat Management Area. The topography the road traverses is barren with little to no vegetation and no suitable sensitive habitats. The road turns to dirt just beyond the Wildcat Loadout Facility and is used to access private lands as well as other public lands and their associated opportunities. These include other ROWs, Gordon Creek Off Highway Vehicle trail, coal bed methane fields, and livestock grazing permits and facilities. The analysis does not address roadways beyond Consumers Road because oil production, and its transportation on other roads and rails, is occurring regardless of this transloading expansion and will continue to occur regardless of the alternatives in this EA (see sections 3.1 through 3.3).

On Consumers Road, UDOT began tracking the Average Annual Daily Traffic (AADT) in 2003 (UDOT 2025). AADT is a unit of measurement that represents the average number of vehicle trips on a segment of road or highway. It represents traffic for both directions of travel. Figure 3-1 depicts data from UDOT regarding the AADT on Consumers Road from 2003 through 2023. As shown in Figure 3-1 (note that oldest data on the right and the most recent data is on the left, so the graph must be read from right to left to see the change over time):
From 2003 through 2010, the AADT ranged from 440 to 800 vehicles on the road.
From 2012 through 2014, the AADT was 1,300 vehicles due to coal transloading activity.
From 2015 through 2023 (the latest available AADT available for Consumers Road), AADT ranged from 240 to 300 vehicles.

[7] *About ¼ mile past the Wildcat Facility, Consumer's Road becomes a crowned and graveled road that provides access to public lands.*

Figure 3-1: AADT on Consumers Road from 2023 through 2003 including the Proposed Action's Additions.



3.4.2. Environmental Effects

3.4.2.1. Alternative A (No Action)

Currently, there is an average of 77 oil tanker truck deliveries per day to the Wildcat Loadout Facility. This activity would continue under the No Action alternative. To account for trucks traveling roundtrip (into the facility and out from the facility) for delivery of product, this would result in a total of 154 truck passes on Consumers Road. Truck passes associated with oil transloading at the Wildcat Loadout Facility began in 2013 and are therefore included in UDOT's 2013 to 2023 AADT.

If BLM were to select the no action alternative, CEG2 has indicated that they would construct facilities on their existing TLA lease to meet their total target throughput of 100,000 bbls per day. In that scenario, the same amount of oil tanker truck traffic predicted under the Proposed Action would occur on Consumers Road. However, an additional mile of existing dirt road west

of the train tracks would be traversed by the trucks to reach the TLA leased facilities. See Figure 2-1, the west half of the dirt road loop directly north of the Wildcat Loadout Facility pin.

3.4.2.2. Alternative B (Proposed Action)

The Proposed Action would add an average of 345 additional oil tanker truck deliveries per day to the Wildcat Loadout Facility (690 truck passes on Consumers Road, which accounts for the round-trip activity). To provide an estimate of the impacts, Figure 3-1 added those 690 truck passes to the AADT 2020 data. Ignoring other vehicle trends, for which the BLM and UDOT has no data, the Proposed Action alternative would put Consumers Road AADT at 990 AADT (690 truck passes 300 AADT; note the AADT includes all traffic on the road (e.g., recreational, grazing permittees, private landowners, oil tanker trucks, etc.)) which is lower than the AADT on that road in 2012 through 2014. CEG2 has proposed a maximum unloading of 100,000 bbls per day to eliminate the risk of traffic backup onto Consumers Road.

The BLM does not have data for accidents on Consumers Road. Nationally, the average vehicle crash rate is approximately 203 crashes per 100 million vehicle miles20 (NHTSA 2021). In the analysis area, the crash rate is lower than this estimate (the data provides only crash numbers, neither source explains why the crash rate in Carbon County is lower than the national average). In 2021, Carbon County had 88 crashes per 100 million vehicle miles, and Duchesne County had 105 crashes per 100 million vehicle miles (UDOT 2023). The Carbon County crash rate presumably includes crashes on Consumers Road. It would take 113 years for the Proposed Action to reach 100 million vehicle miles (and 105 crashes), thus the Proposed Action's effect on traffic may result in less than 1 crash per year[8].

Accidental spills of petrochemicals during a crash could degrade surface water quality should it occur in the wash when the wash is moving water, which could adversely affect aquatic habitat. As disclosed in AIB-21, the nearest water is Price River, which is 0.1 mile east of the Consumers Road intersection with Highway 6 and 2.5 miles from the Wildcat Loadout Facility. Uinta Basin black and yellow crude oils are waxy crude oils that do not flow except at high temperatures and if spilled onto land, tend to not disperse, and if spilled in water, tends to form globules of semisolid material that can be cleaned up by hand (if in water) or by shovel (if on land) (STB 2021). The Stormwater Pollution Protection Plan (SWPPP) contains site-specific measures to avoid and minimize petrochemical spills that could cause water quality impacts.

If the force of an accident were sufficient to ignite the crude oil, a fire could result that could cause the truck's tank to rupture. The BLM is not aware of this happening historically on Consumers Road. Given the paved roadway, and the badlands nature of the lands around the existing road, the risk of damage to other vegetation and habitats from a fire would be low.

The BLM does not have data for animal strikes for Consumers Road. However, Pagany 2020 synthesizes the findings of various wildlife-vehicle collusion studies regarding vehicles and animal strikes. It shows that number of animal strikes may be positively or unclearly correlated

[8] *3.5 miles x 2 trips (in and out)) =7 miles. 7 miles x 345 vehicles per day = 2,415 vehicle-miles per day. 2,415 vehicle-miles per day x 365 days per year = 881,475 vehicle miles per year. 100 million vehicle miles / 881475 vehicle miles per year = 113 years*

to either traffic volume or speed depending on species. The speed of Consumers Road is 35 miles per hour. However, the speed limit is outside the BLM's control, but the BLM assumes it will remain at 35 miles per hour. Therefore, there may be an increase in the number of animal strikes associated with the increased volume of oil tanker truck traffic. The BLM also anticipates a proportional change in noise and light effects from the additional tanker truck traffic to nearby wildlife, which may include displacement and disturbance.

Regarding traffic volumes and its relationship to road maintenance frequency, the BLM found two studies for nearby Highway 191, UDOT 2024 and Feula 2022, which may inform the maintenance needs from oil tanker truck traffic for Consumers Road. First, the United States Road Assessment Program identified portions of Highway 191 as having potential hazards related to road surface integrity, shoulders, passing lanes, and guardrails (UDOT 2024). Second, the U.S. 191 Traffic Volume and Level of Service Projections study prepared for UDOT (Feula 2022) projected Highway 191's total average daily traffic in 2030. The study estimated a baseline in 2022 of 1,400 total average daily traffic. The study estimated a 2030 projected total average daily traffic of 3,100. To determine Highway 191's level of service in 2030, the study then used daily passenger car equivalents to convert the 2030 daily traffic projection into terms of passenger cars. It projected the 2030 passenger car equivalent to be 10,550 total average daily traffic. The level of service calculations helped UDOT identify which portions of Highway 191 need improvements to maintain vehicle safety and road integrity. Regarding differences between the two roads which limits the applicability of the Highway 191 data to Consumers Road, it is important to note that Highway 191 has a baseline average daily traffic volume (1,400 in 2020) similar to Consumers Road's historic high AADT (1,300 AADT in 2012-2014). Highway 191 is longer (44 miles) compared to Consumers Road (3.5 miles). Highway 191 also traverses mountain topography compared to Consumers Road's foothills topography. Therefore, the BLM assumes there may be a positive relationship between the volume of traffic from the Proposed Action and the maintenance frequency of the road though it is estimated to be lower than that projected for Highway 191 due to the lower traffic volumes.

If the BLM approves the Proposed Action, CEG2 has indicated that they would construct additional railway sidings for assembling trains and empty railway car storage on the leased TLA lands near the Wildcat Loadout Facility.

3.4.2.3. Past, Present, and Reasonably Foreseeable Effects

The BLM and UDOT do not have data regarding vehicle trends on Consumers Road, but the BLM presumes that vehicles accessing these other opportunities will remain stable or increase in the future. According to CEG2, the ten unloading lanes allows twenty (20) trucks per hour to be processed through the facility leading to a total possible throughput of up to approximately 480 trucks per day (960 passes per day) equaling a maximum unloading capacity of 150,000 bbl per day. If Utah Department of Air Quality were to issue an updated air permit allowing emissions on throughput of 150,000 bbl per day, the BLM presumes that oil tanker trucks accessing the Wildcat Loadout Facility may at times queue on Consumers Road. Under this scenario, the BLM presumes CEG2 would either work with the County to amend the Consumers Road ROW to create a turning lane or amend the Wildcat ROW to create a parking area. Neither action has been requested at this time and neither is foreseeable at a maximum throughput of 100,000 bbl per day under CEG2's current State-issued air permit.

3.5. Issue 2: What impacts would occur because of the increase in rail traffic between Wildcat Loadout Facility and Martin Yard?

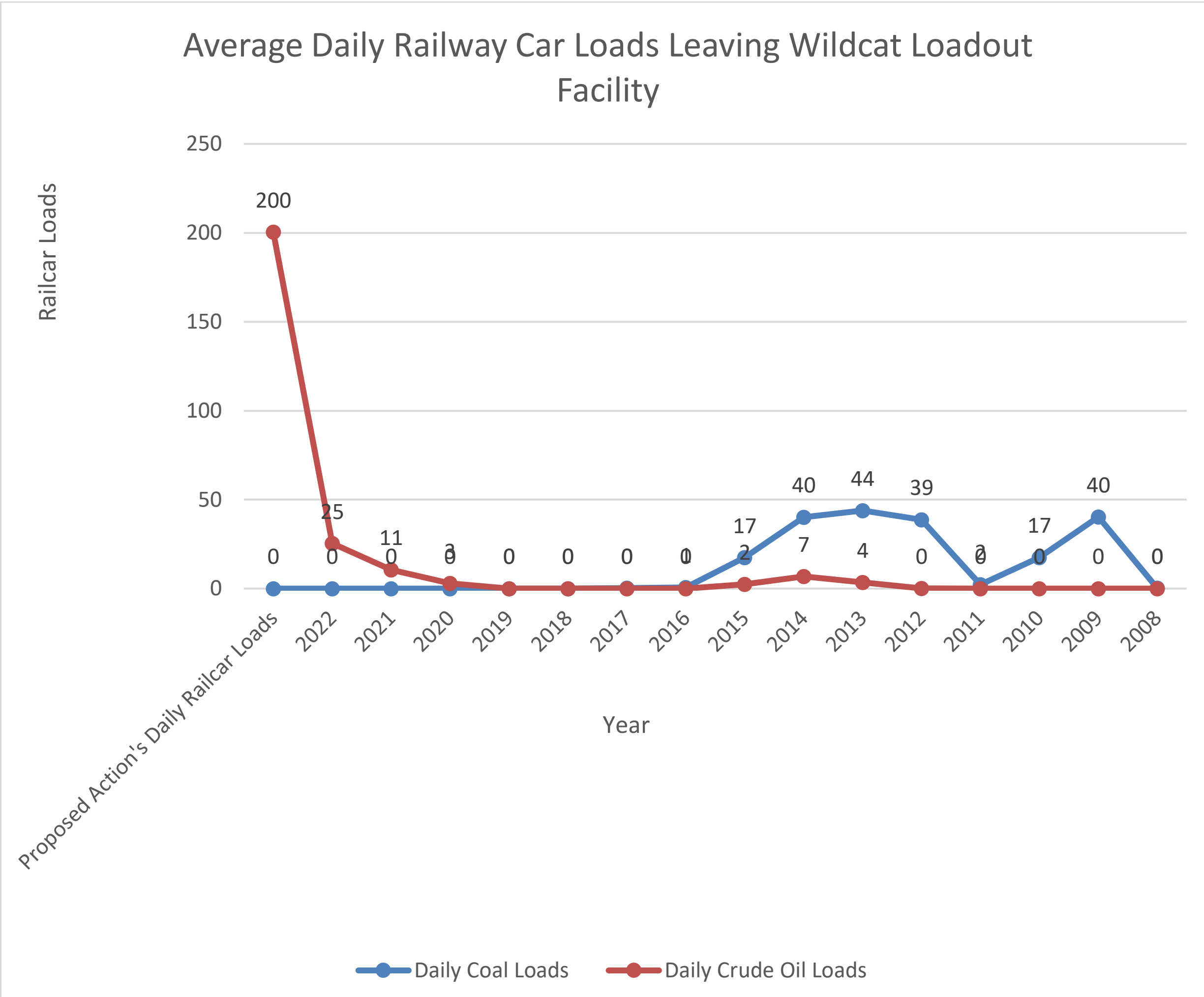
3.5.1. Affected Environment

The Wildcat Loadout Facility has been used as a coal loadout for the railway since the 1920s. It is near and overlaps Utah Railway's ROW UTU10655575 which includes railway and sidings for the Wildcat Loadout Facility and connecting the facility to the Martin Yard (see Figure 2-1). There are approximately five miles of track between the Wildcat Loadout facility and the Martin Yard. Approximately 1 mile is within Greater sage-grouse General Habitat Management Area. The track goes through foothill type elevation and directional changes which, combined with short distance, necessitate a slow train speed. The topography the track traverses is barren with little to no vegetation and no sensitive habitats. Only the Wildcat Loadout Facility uses this segment of track. The analysis does not address railways beyond the Martin Yard because oil production, and its transportation on other roads and rails beyond this point, is occurring regardless of this transloading expansion at Wildcat and will continue to occur regardless of the alternatives in this EA (see section 3.1). During the time that the track between the Wildcat Loadout facility and the Martin Yard has been used for loadout purposes, the BLM has not heard of any accidents or derailments.

Figure 3-2 depicts data provided by Union Pacific to CEG2 regarding the average daily railway car loads (both coal and oil) leaving the Wildcat Loadout Facility from 2022 through 2008. As shown in Figure 3-2 (note that oldest data on the right and the most recent data is on the left, so the graph must be read from right to left to see the change over time):

- From 2009 through 2016, the average daily railway car loads ranged from 3 to 48, mainly due to coal transloading activity. Note that Utah Rail's data shows that oil transloading occurred in 2013 and 2014 though the BLM did not approve the ROW modification for permanent transloading equipment until September 2014. This prior transloading was done through mobile equipment that did not require a ROW modification or BLM approval because it was casual use under 43 CFR 2801.5 (b) (see BLM 2014 section 4.4.6.2 which states that 6,000 bbls per day were already being transloaded).
- From 2020 through 2022, the daily railway car loads ranged from 3 to 25, mainly due to oil transloading activity.
- In 2008, and 2017 through 2019, the daily railway car loads were so low as to not register a daily average. The year 2008 had a total of 85 railway car loads shipped the entire year, 2017 had 94, and 2018 and 2019 had zero.

Figure 3-2: Average Daily Railcar Loads Leaving Wildcat Loadout Facility from 2022 through 2003 including the Proposed Action's Additions.



3.5.2. Environmental Effects

3.5.2.1. Alternative A (No Action)

Currently, up to 35 railway car loads leave the Wildcat Loadout Facility daily. This activity would continue under the No Action alternative. Doubling that number to account for empty railway cars coming in, a total of 70 daily railway cars pass between Martin Yard and Wildcat Loadout Facility. Railway car passes associated with oil transloading at the Wildcat Loadout Facility began in 2013 and are therefore included in Utah Rail's 2013 to 2022 data.

If BLM were to select the no action alternative, CEG2 has indicated that they would construct facilities on their existing TLA lease to meet their total target throughput of 100,000 bbls per day. In that scenario, the same amount of railway car truck traffic predicted under the Proposed

Action would occur on the Utah Rail's ROW between the Wildcat Loadout Facility and Martin Yard.

3.5.2.2. Alternative B (Proposed Action)

The Proposed Action would add up to 175 additional oil tanker truck deliveries per day to the Wildcat Loadout Facility. To provide an estimate of the impacts of those oil tanker truck deliveries on rail traffic between the loadout facility and Martin Yard, Figure 3-1 added those 175 truck passes to the Utah Rail 2022 data. Based on that data, the Proposed Action would result in an average of 200 daily railway car loads, which is three times more railway car loads than currently occurs. When accounting for empty railway cars delivery, the proposed action would result in 400 daily railway car passes.

In 2019, there were 1,869 train accidents in the U.S. across all track types and across all railroads; 607 of these were on main lines or sidings (Federal Railroad Administration (FRA) 2020). To estimate railway accidents, the BLM extrapolated data from the Uinta Basin Railway (Surface Transportation Board (STB) 2021). The Uinta Basin Railway anticipated between 4 trains and 11 trains per day (STB 2021). STB 2021 predicted that rail accidents would occur approximately once every 3 to 10 years and that a spill could occur once every 14 to 40 years with the chance of the spill occurring in a sensitive area such as a waterway being smaller because of the small amount of the railway falling within sensitive areas. The Wildcat Loadout Facilities would move three 35-car units per day to the Martin Yard. Given the slow speed due to the elevation change and short mileage, the lack of sensitive habitats other than one ephemeral wash and given there are no other trains on the track, the BLM believes the accident and spill rates between the Wildcat Loadout Facility and the Martin Yard will be negligible.

Accidental spills of petrochemicals could degrade surface water quality should they occur in the wash when the wash is moving water, which could adversely affect aquatic habitat. As disclosed in AIB-21, the nearest water is 2.5 miles east of the existing railway. Uinta Basin black and yellow crude oils are waxy crude oils that do not flow except at high temperatures and if spilled onto land, tend to not disperse, and if spilled in water, tend to form globules of semisolid material that can be cleaned up by hand (if in water) or by shovel (if on land) (STB 2021). The SWPPP contains site-specific measures to avoid and minimize petrochemical spills that could cause water quality impacts.

If the force of an accident were sufficient to ignite the crude oil, a fire could result that could remain confined to a single car or could surround other cars and cause them to rupture if the thermal protection on the other cars were breached or damaged. A fire that surrounds other cars could, in turn, cause a larger fire. Similarly, if the train were to result in a sparking[9] the cheatgrass along the route might catch fire. The BLM is not aware of this happening historically on the rail between the Wildcat Loadout Facility and the Martin Yard. Given the gravel base under the railway, and the badlands nature of the lands around the existing railway, the risk of damage to other vegetation and habitats from a fire would be low.

[9] *https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r21v0143/r21v0143-20210715.html*

The BLM does not have data for animal strikes for the rails between the Wildcat Loadout Facility and the Martin Yard. However, the BLM assumes the effects are similar to vehicle strikes as synthesized in Pagany 2020 which shows that number of animal strikes may be positively or unclearly correlated to either traffic volume or speed depending on species. In STB 2021, the maximum speed for a loaded train was estimated to be 10 to 20 miles per hour, which would likely be slow enough for large and medium sized animals, including eagles, to see and hear the train in advance of a potential strike, allowing animals to flee the area. Given the short distance of the Wildcat Loadout Facility to Martin Yard track, and the weight of a fully loaded unit, the speed between the Wildcat Loadout Facility and the Martin Yard is likely to be lower than 20 miles per hour. Given the increased number of 35-car units moved on the track (three per day instead of one per day), there may be an increased potential for animal strikes, but the potential is still expected to be low due to the slow speed of the train.

The BLM also anticipates a change in noise and light effects to nearby wildlife proportional to the additional 35-car units and that, similar to traffic, different species will respond differently, and responses are expected to range from disturbance to habituation. In STB 2021, the noise disturbance study area was defined by the 100 A-weighted decibel (dBA) sound exposure level (SEL), the noise level at which studies have shown animals (domestic and wild) exhibit a response to train noise (FRA 2005). Based on noise modeling for the [Uinta Basin Railway], the 100-dBA SEL is estimated to extend 350 feet from the rail line for wayside (locomotive engine and wheel on rail) noise and 460 feet for horn noise at grade crossings. The increased noise would only occur until the train passes. STB 2021 predicted that noise-related effects on wildlife would mostly occur within approximately 350 feet of the [Uinta Basin Railway]. This is the distance at which wayside noise levels would be at or above 100 dBA SEL, the noise level at which studies have shown animals (domestic and wild) exhibit a response to train noise (FRA 2005). For horn noise at grade crossings, noise-related effects could occur out to approximately 460 feet from the locomotive. Noise levels beyond this distance are not expected to adversely affect wildlife (FRA 2005). The BLM anticipates similar effects from the increased railway car traffic between the Wildcat Loadout Facility and the Martin Yard.

If the BLM approves the Proposed Action, CEG2 has indicated that they would construct additional railway sidings for assembling trains and empty railway car storage on the leased TLA lands near the Wildcat Loadout Facility.

3.5.2.3. Past, Present, and Reasonably Foreseeable Effects

The railway sidings in the Wildcat Loadout Facility ROW are used exclusively for that facility as is the track between the Wildcat Loadout Facility and the Martin Yard. The BLM was unable to obtain railway shipping numbers for the Union Pacific railway transportation routes outside of the Wildcat Loadout Facility because the BLM was told this data is protected for national security reasons. However, the BLM presumes the number of trains using that railway will remain stable or increase in the future.

CHAPTER 4. PUBLIC INVOLVEMENT, CONSULTATION AND COORDINATION

4.1. Public Involvement

On June 5, 2023, the BLM posted to ePlanning a website dedicated to the Wildcat ROW modification request. Several members of the public submitted letters of interest in the project with scoping-level comments including possible alternatives for consideration and concerns to be considered. The alternatives eliminated from detailed analysis described in section 2.4 of this EA address those proposed alternatives. The concerns identified and considered by the BLM include:
The project's relationship to the paving of Gate Canyon and traffic in Nine Mile Canyon,
The project's relationship to oil production in the Uinta Basin with the attendant air and water impacts,
Oil trains moving through Colorado with their potential for accidents, oil spills, and wildfires in or adjacent to the Colorado River headwaters and any resulting endangered fish impacts,
The combustion of oil with the attendant air and climate impacts, and
The impacts of the trucks on the roads.
The BLM also received multiple requests for a public comment period.

On April 23, 2025, CEQ authorized the use of alternative arrangements to comply with the NEPA before taking urgently needed actions (43 CFR 46.150) for projects that respond to the national energy emergency (EO 14156).

On May 1, 2025, CEG2 requested that BLM process its Wildcat Loadout Facility ROW amendment under alternative arrangements for NEPA compliance.[10] On June 19, 2025, the request was approved by the Acting Assistant Secretary – Land and Minerals Management Under the Alternative Arrangements for NEPA Compliance, the Responsible Official is not required to seek public comment prior to finalizing the EA. The BLM published the project on ePlanning on June 18, 2025.

4.2. Consultation and Coordination

Tribal consultation letters were mailed and emailed on May 8, 2025. The Paiute Tribe of Utah responded on June 16, 2025, requesting to participate in the NEPA process. This consultation is ongoing as of June 17, 2025.

One previously recorded site as eligible for the National Register of Historic Places (NHPA) was revisited and no contributed features were observed. One isolated find was documented and determined not eligible for the NRHP. The BLM has made an undertaking determination of no historic properties affected directly and indirectly (physically, visually, auditorily and

[10] *The President issued Executive Order (EO) 14156 "Declaring a National Energy Emergency" on January 20, 2025, which directed heads of executive departments and agencies to "facilitate the … transportation, refining, and generation of" energy resources on Federal lands. Secretary's Orders No. 3417 and 3418 implemented provisions of EO 14156 and directed Bureaus and Offices under the Department of the Interior to identify any emergency authorities to facilitate "energy projects" as defined by EO 14156. On April 23, 2025, the Council on Environmental Quality (CEQ) authorized the use of alternative arrangements to comply with the National Environmental Policy Act (NEPA) before taking urgently needed actions (43 Code of Federal Regulations (CFR) 46.150) for projects that respond to the national energy emergency.*

atmospherically). As the site has no contributing features and isolated finds are not eligible for the NRHP, there would be no significant impact to cultural resources from this Proposed Action. Due to the project size and finding of effect, the report was sent to SHPO under the Small-Scale Programmatic Agreement and received April 12th, 2024 (Case No. 24-0813).

Section 7 Consultation conducted under the Endangered Species Act was not necessary because there are no listed species or habitat present. See Table 1-5, and Appendix AIB-24 and AIB-26.

CHAPTER 5. LIST OF PREPARERS

Table 5-1: List of Preparers.

Name	Title	Area of Responsibility
Kyle Beagley	Assistant Field Manager – Lands and Minerals	Lands and Realty
Tyler Elgiar	Natural Resource Specialist (Air)	Air Quality
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Stephanie Howard	Branch Chief: NEPA & GIS	Quality Assurance, Traffic, Trains
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GLOSSARY OF TERMS

Ancillary Track: Additional rail tracks besides the Utah Railway mainline located in the Martin Yard.

Annual average daily traffic: Average number of vehicles passing a point on a road in a day.
At-grade road-crossing: The intersection between a road and a railroad that occurs at the level of the tracks.

Badlands: Extensive tracts of heavily eroded, uncultivable land with little vegetation.

Burlington Northern Santa Fe Railway: One of Coal Energy Group 2's railway partners.

Coal Energy Group 2: The holder of the Wildcat Loadout Facility Right-of-Way.

Coal loadout facility: A facility where coal is stored and loaded onto railway cars.

Common header: A section of pipe that has multiple connections connected to it to direct the flow to a single source/outlet.

Consumers Road: Milepost 21 (Consumers Road's intersection with Highway 6) to Milepost 12 (Consumers Road's intersection with the Wildcat Facility).

Crude oil operation: Transfer of crude oil from truck to railway cars either directly from truck to railway car (called transloading) or indirectly using truck unloading racks, storage tanks, and railway car loading racks.

Detonation arrestors: An element within vapor piping that, in the event of a detonation in the pipe, would collapse to close off the pipe and stop the detonation.

Down Shielded Lighting: Lights with shields that direct the light downward.

Drip legs: A section of horizontal pipe within an otherwise vertical piping that collects condensed materials for recycling back into the product stream.

Gate Canyon: An unpaved segment of Wells Draw Road that connects Highway 40 to Nine Mile Canyon Road.

Gulf Coast refineries: The Texas and Louisiana refineries with contracts to process the crude oil being transloaded by the Wildcat Loadout Facility.

Highway 6: Milepost 233 (Highway 6's intersection with Highway 191 in Indian Canyon) to Milepost 230 (Highway 6's intersection with Consumers Road).

Highway 191: Milepost 296 (Highway 191's intersection with Highway 40 in Duchesne) to Milepost 251 (Highway 191's intersection with Highway 6 north of Helper, UT). Also called Indian Canyon.

Highway 40: Milepost 86 (Highway 40's intersection with Highway 191 in Duchesne) to milepost 130 (Highway 40's intersection with Highway 88 to Ouray).

Leased TLA Lands: 51.61 acres of lands administered by Utah's Trust Lands Administration adjacent to the existing Wildcat Loadout Facility.

Level of Service: A mechanism used to determine how well a roadway is operating from a traveler's perspective. Typically, six levels of service are defined, and each is assigned a letter designation from A to F, with LOS A representing the best operating conditions, and LOS F the worst.

Loading racks (also railway car loading racks): Equipment capable of loading crude oil into railway cars from onsite storage tanks.

Landing platform: A platform on top of the tank that has appropriate handrails and other guards to allow an operator to safely access any equipment at the top of the tank.

Loadout Truck Bays: The area a truck will enter to use the unloading racks.

Martin Yard: A railroad yard in Helper Utah.

Mobile Pumping Station: Mobile equipment used to transload crude oil from oil tanker trucks to railway cars.

Motor Control Center: A container for electrical feeds for the Wildcat Loadout Facility, i.e. motor starters, variable frequency drives, electrical breakers, etc.

Knock-out pots: A vessel that collects condensed materials prior to entry into process equipment.

Oil tanker truck: A semi-truck transporting crude oil from the Uinta Basin oil fields to the Wildcat Loadout Facility. An oil tanker truck is classified by UDOT as a combination unit truck.

Oil tanker truck delivery: The unloading or transloading of Uinta Basin crude oil from a single tanker truck.

Oil tanker truck pass: The number of truck passes measured at a point on a road. For example, one oil tanker truck delivery at Wildcat Loadout Facility would result in two oil tanker passes (entering and exiting) on Consumers Road.

Oil Train: One hundred and four (104) oil-carrying railway cars joined together.

Proctor: The maximum density for the soil at its optimum moisture content.

Product Stream: The product flow in a pipeline.

Railway car: A wheeled vehicle adapted to the rails of railroad, in this case for the purpose of hauling crude oil.

Railway car unit: Approximately thirty-five (35) railway cars joined together.

Rail tracks: A set of two parallel rows of long pieces of steel are used by trains to transport people or product.
Reference Area: An undisturbed area established for comparison of vegetation cover to judge reclamation success of a nearby disturbed area.

Substation: Equipment that reduces the high voltage of electrical power transmission to that suitable for supply to consumers.

Throughput: Barrels of crude oil being transferred daily thru the Wildcat Loadout Facility.

Transloading: The process of moving product (such as coal or crude oil) from trucks directly into railway cars without interim steps such as onsite storage.

Transloading facility: Equipment that makes possible the moving product (such as coal or crude oil) from trucks directly into railway cars without interim steps such as onsite storage>

Uinta Basin crude oil: Unrefined petroleum produced in the Uinta Basin.

Uinta Basin railway: An approved common-carrier railway for moving goods from the Uinta Basin to the railway system near Highway 6 and Soldier Summit. The railway is not yet built.

Union Pacific Railroad: One of Coal Energy Group 2's railway partners.

Unloading racks (also oil tanker truck loading racks): Equipment capable of unloading crude oil from oil tanker trucks into onsite storage tanks.

Utah Railway: One of Coal Energy Group 2's railway partners.

Utah Railway mainline: The main railway track used for through trains.

UTUT105525661: ConocoPhilips Company/Scout Energy Group/XTO Energy Oil and Gas Lease

UTUT106107053: Carbon County's Access Road

UTUT105884090: Carbon County's Geezer Backbone Trail

UTUT106092525: PacifiCorp doing business as Utah Power and Light's 48-kV powerline ROW near the Wildcat Loadout Facility.

UTUT105987487: Emery Telcom's buried communication line ROW near the Wildcat Loadout Facility.

UTUT106262560: CEG2's 270-acre ROW known as the Wildcat Loadout Facility.

UTUT106099056: Carbon County's Consumer Road ROW.

UTUT106235040: CEG2's ROW overlapping UTUT106262560 containing additional facilities.
UTUT106155575: Utah Railway's ROW containing their mainline and rail sidings that connect the Wildcat Loadout Facility with the Martin Yard in Helper Utah.

UTUT106103913: Pacificorp ROW for a switchrack (Beaver Creek Coal Tap to Tower Resources)

UTUT106107053: Carbon County access road to Wildcat Loadout

Vapor Balancing: The process of crude oil from an oil tanker truck into a railway car displacing vapors in the railway car which are then captured and returned via a hose to the truck. The vapors in the oil tanker truck usually condense back to liquids during the truck's return trip, which then mixes in with the next crude oil load.

Vapor combustion unit: Equipment capable of combusting any vapors generated during the railway car loading process.

Wildcat Loadout Facility: CEG2's 270-acre ROW for transloading crude oil from oil tanker trucks to railway cars

LIST OF ACRONYMS

AADT = annual average daily traffic

ACEC = Area of Critical Environmental Concern

API = American Petroleum Institute

bbl per day = barrels per day

bcf/day = billion cubic feet per day

BLM = Bureau of Land Management

CAA = Clean Air Act

CAP = Criteria Air Pollutant

CEG2 = Coal Energy Group LLC

CFR = Code of Federal Regulations

CH4 = Methane

CO = Carbon Monoxide

CO2 = Carbon Dioxide
CO2e = Carbon Dioxide Equivalent

dBA = decibel

EIA = U.S. Energy Information Administration

EPA = Environmental Protection Agency

ESA = Endangered Species Act

FLPMA = Federal Land Policy and Management Act

GHG = Greenhouse Gases

GRD = Green River District

GRSG = Greater Sage Grouse

HAP = Hazardous Air Pollutants

ID = interdisciplinary

JNM = Jurassic National Monument

LEPC = Local Emergency Planning Committee

Mt = Megatonnes

MG = motor and generator

MLRS = BLM's Mineral & Land Record System

MRP = mining and reclamation plan

MSHA = Mine Safety and Health Administration

N2O = Nitrous Oxide

NAA = Nonattainment Area

NAAQS = National and Utah Ambient Air Quality Standards

NEMA= National Electrical Manufacturers Association

NEPA = National Environmental Policy Act

NHPA = National Historic Preservation Act

NOx = Nitrogen Oxides

NO2 = Nitrogen Dioxide

NRHP = National Register of Historic Places

OPM = Office of Personnel Management

OSHA = Occupational Safety and Health Administration

PFO = Price Field Office

PFYC = Potential Fossil Yield Classification

PMLU = post mining land use

PM2.5 = Particulate Matter with diameters that are generally 2.5 micrometers and smaller

PM10 = Particulate Matter with diameters that are generally 10 micrometers and smaller

ppb = Parts per Billion

ppm = Parts per Million

PSD = Prevention of Significant Deterioration

PSM RMP= Process Safety Management standard and Risk Management Program

PUP = Pesticide Use Permit

RCRA = Resource Conservation and Recovery Act

RMP = Resource Management Plan

ROD = Record of Decision

ROW = Right-of-Way

SARA = Superfund Amendments and Reauthorization Act

SDS = Safety Data sheets

SERC = State Emergency Response Commission

SMCRA = Surface Mining Control and Reclamation Act

SO2 = Sulfur Dioxide

SPCC = Spill Prevention Control and Countermeasure Plan

STEO = Short-Term Energy Outlook

TEFC = Totally Enclosed Fan Cooled

TEPC = Tribal Emergency Planning Committee

TERC = Tribal Emergency Response Commission

TLA = Utah Trust Lands Administration

Tonnes = Metric Tons

UDOGM = Utah Division of Oil, Gas, and Mining

UDOT = Utah Department of Transportation

UPDES = Utah Pollutant Discharge Elimination System

U.S. = United States

USGS CONUS = United States Geological Society Conterminous United States reference data project

VOC = Volatile Organic Compounds

VRM = Visual Resource Management

WSA = Wilderness Study Area

WSR = Wild and Scenic River

A. APPENDIX A – ISSUES ANALYZED IN BRIEF

The following issues are analyzed in brief because they do not relate to how the Proposed Action or alternatives respond to the purpose and need or they have no potential for significant impacts.

A.1 – AIB-1 (Air Quality)

How would emissions associated with facility construction and operation affect ambient air quality in Carbon County?

The Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants (CAPs) considered harmful to public health and the environment: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb). Oxides of nitrogen (NO_x) and volatile organic compound (VOC) emissions also contribute to secondarily formed pollutants of O_3 and $PM_{2.5}$ through a complex series of atmospheric chemical interactions. A detailed description of these pollutants, along with their health effects and their sources can be found on pages 6-10 of the BLM Utah Air Monitoring report (BLM 2024b). The EPA has established NAAQS for each of the criteria air pollutants (EPA 2023a). Air quality design values are statistical metrics, typically based on monitored data of ground-level atmospheric air pollutant concentrations over a three-year period, used to determine whether an area is in compliance with the NAAQS. Current design values for the 2022-2024 period are available from the EPA (EPA 2024a).

An airshed is a geographic area where air pollutants from various sources are likely to mix and affect air quality under the same atmospheric conditions. The scope of this analysis is Carbon County to best represent the airshed of this project. The selection also facilitates the analysis by using the best available air quality monitoring data, generally provided at the county level. Carbon County is designated as attainment for all NAAQS pollutants. Design values for Carbon County are presented in table A-1.

Table A-1. 2022-2024 Criteria Air Pollutant Design Values

Pollutant	County	Averaging Time	Design Value[1]	NAAQS	Percent of NAAQS
O_3	Carbon	8-hour	0.062 ppm[11]	0.070 ppm	90.0%
NO_2	Carbon	Annual	2 ppb	53 ppb	3.8%
NO_2	Carbon	1-hour	15 ppb[12]	100 ppb	15%

Source: EPA 2023b, retrieved from https://www.epa.gov/air-trends/air-quality-design-values

[11] Concentrations in parts per million (ppm) and parts per billion (ppb).

[12] The 1-hour design value for NO_2 is listed as invalid on EPA's website but has been included in the table to provide additional context to current conditions in Carbon County. It should also be noted that invalid design values cannot be used for attainment decisions by the Utah Department of Air Quality or the EPA.

Hazardous air pollutants (HAPs) are chemicals or compounds that are known or suspected to cause cancer or other serious health effects, such as compromises to immune and reproductive systems, birth defects, developmental disorders, or adverse environmental effects and may result from either chronic (long-term) and/or acute (short-term) exposure. The EPA's Air Toxics Screening Assessment (AirToxScreen) is used to estimate cancer and non-cancer health risks from air toxics across the United States based on emissions data, modeling, and monitoring. A cancer risk of less than 100 in one million (EPA 2024b) is considered within the acceptable range of exposure. The 2019 AirToxScreen assessment reports the total cancer risk in Carbon County as 12.33 in one million. A hazard index is a ratio that sums potential non-cancer health risks from multiple air toxics affecting the same target receptor, indicating the potential for adverse health effects. The hazard indices for Carbon County range from 0 to 0.12. A hazard index value less than one is not likely to be associated with adverse health effects (EPA 2024b).

The Proposed Action would result in CAP and HAP emissions associated with construction and operation. Construction emissions would be temporary (during construction only) and would originate from vehicle travel to and from the project location as well as from heavy construction equipment used to construct the facility. Operation would result in emissions from vehicle travel to and from the project location, unloading and loading activities, oil tanker trucks, railway cars and oil trains, stationary heaters, storage tanks, and a vapor combustion unit.

The Proposed Action would result in direct and indirect emissions of CAPs and HAPs. Direct emissions would result from construction activities, which would be temporary (during construction only), and operation of the facility. Construction emissions would include NO_x, SO_2, and CO tailpipe emissions from construction equipment and vehicle travel to and from the site. Fugitive dust (PM_{10} and $PM_{2.5}$) emissions would occur from vehicle traffic, construction equipment, and from wind erosion where soils are disturbed. During operation, NO_x, CO, and VOC emissions would originate from vehicle and equipment tail pipes, railway cars and oil trains, stationary heaters and engines, a vapor combustion unit, and loading and unloading activities. HAP emissions would also occur from storage tanks, loading and unloading activities, and other operational equipment. Indirect emissions would include truck tailpipe emissions from the transportation of oil to and from the Wildcat Loadout facility, train engine emissions and fugitive dust emissions from vehicle travel. The indirect emissions for this project would be dispersed over a large area throughout Uintah, Duchesne, and Carbon Counties.

Since oil hauling truck traffic in Uintah and Duchesne Counties is not anticipated to increase (see Analysis Assumption 4) emissions from truck traffic in those counties would also not increase. However, the Proposed Action would allocate existing oil hauling truck traffic from other facilities (within and outside of Carbon County) to the Wildcat Loadout Facility (Analysis Assumption 5). Therefore, emissions in Carbon County would increase from the truck traffic allocated from facilities outside of Carbon County. At the time of this analysis, it is uncertain how much of the truck traffic would be allocated from facilities outside of Carbon County. As a conservative estimate, total indirect emissions from crude oil hauling truck traffic that would occur within Carbon County are reported in the table below. Emissions from train engines traveling from the Wildcat Facility were calculated based on the one-way distance to the Martin Rail Yard (see section 3.6) and are included in the indirect emissions estimates presented below.

Emissions were estimated using company provided inputs and emissions factors from EPA's AP-42 and MOVES (Motor Vehicle Emissions Simulator) model. Emissions associated with the Proposed Action compared to county level emissions are presented in Table A-2.

Table A-2. Proposed Action's Emissions Compared to County Level Emissions.

	Emissions (Tons per Year)						
	VOC	**PM_{10}**	**$PM_{2.5}$**	**CO**	**NO_x**	**SO_2**	**HAPs**
Facility Construction	0.01	3.69	1.83	0.03	0.07	<0.01	<0.01
Facility Operation	26.02	2.46	0.71	8.94	6.15	0.53	2.96
Total Direct Emissions[1]	26.03	6.16	2.54	8.97	6.22	0.53	2.96
Indirect Emissions[2]	2.16	41.14	11.09	8.23	31.07	0.10	0.02
Total Project Emissions	**28.19**	**47.30**	**13.63**	**17.20**	**37.29**	**0.64**	**2.98**
Carbon County[3]	8,904.5	3,324.3	502.27	5,289.8	1,728.4	451.1	1,238.0
Project Contribution[4]	0.32%	1.39%	2.66%	0.33%	2.16%	0.14%	0.24%

1 – Direct emissions include construction and operation of the Wildcat Loadout Facility.
2 – Indirect emissions include emissions from crude oil hauling truck traffic that would occur within Carbon County and trains that would travel from the facility to the Martin Rail Yard.
3 – County level emissions are from the National Emissions Inventory. Retrieved from: https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data
4 – Percent contribution of the Proposed Action's emissions to the total emissions in Carbon County.

Utah Administrative Code R307-410-4 provides a list of emission rate thresholds applicable to stationary sources for when dispersion modeling should be performed for air quality permitting in attainment areas. These emissions rates are also listed in 40 CFR 52.21 (b)(23)(i) as part of the prevention of significant deterioration (PSD) rules. Stationary source emission rates below these thresholds are considered de minimis and an emissions review is deemed sufficient to demonstrate no adverse air quality impacts in attainment areas. Emission rates above the threshold would not necessarily have an adverse impact, but rather indicate that additional analysis, such as modeling or other considerations, is needed to verify that there would be no adverse impacts to air quality. The Proposed Action's stationary source (facility operation) emissions would be below the thresholds. It should be noted the facility operation emissions presented in table A-2 also include emissions from mobile sources that would operate at the facility and can be considered a conservative estimate of the facility's stationary source emissions. The company is currently operating under Approval Order DAQE-AN150710004-24. The Approval Order lists emissions control measures that would reduce impacts from the Proposed Action which include but are not limited to paving of haul roads and fugitive emissions monitoring (i.e., Leak Detection and Repair).

Emissions of CAPs and HAPs would also occur outside the planned area from additional transport, processing, distribution, and end-use. Oil transloaded at the Wildcat Loadout Facility is generally transported via railway to refineries on the Gulf Coast where they produce a multitude of refined products. Since combustion of all petroleum products emits CAPs and HAPs, local ambient concentrations of these pollutants could increase in areas where products exported from the Wildcat Loadout Facility are combusted. This could contribute to an area exceeding either national or local air quality standards. Air quality involves complex physical

and chemical transformations at a local/regional level, so impacts would vary considerably depending on background concentrations, meteorology, and other local pollutant sources. If any pollutant concentration is near or above its standard in a particular area, the combustion of oil products could contribute to or exacerbate nonattainment. Potential pollutant concentration change resulting from combustion is therefore often a key driver of public policy to mitigate air quality and public health impacts in such areas. Downstream combustion and end uses are regulated by the EPA or delegated to state agencies. This regulatory process is designed to avoid downstream impacts to regional and local air quality.

Past, present, and reasonably foreseeable impacts for air quality are the result of the incremental impacts from the Proposed Action when added to other past, present, and reasonably foreseeable future actions. Past and present actions that have affected and would likely continue to affect air quality in the analysis area are too numerous to list here but would include: ongoing oil and gas development and associated infrastructure, geophysical exploration, ranching, livestock grazing, range improvements, recreation (including off-highway vehicle use), authorization of rights-of-way for utilities and other uses, road and railway development, development or conversion of power plants, and the development of various industries that emit pollutants.

To assist in airshed management, the BLM has at times utilized air quality modeling. Modeling is based on reasonably foreseeable development. Products from modeling analyses are used for past, present, and reasonably foreseeable impacts analysis and source apportionment impact analysis (i.e., impacts from federal versus non-federal emissions). Results from the BLM Regional Modeling Study are included in the BLM 2023 Utah Air Monitoring Report (BLM 2024a), are incorporated by reference, and briefly summarized below. Additional modeling results (including information on HAPs and air quality related values) can be found on pages 42-59 of the BLM 2024 Utah Air Monitoring Report (BLM 2024b).

In general, past, present, and reasonably foreseeable concentrations for all modeled CAPs in the BLM Regional Air Model showed concentrations that did not lead to any violation of the NAAQS across Utah except for $PM_{2.5}$ and PM_{10}. These particulate exceedances were due to projected wildfire episodes. The BLM Regional Air Model showed that sources outside of Utah have a large contribution to the maximum O_3 concentrations in Utah. The largest contributions to modeled NO_2 and SO_2 concentrations were from other anthropogenic and natural (i.e., wildfires) source categories. Locations with maximum 1-hour CO concentrations also had PM_{10} peaks due to wildfires indicating that wildfires were likely also responsible for the high CO concentrations.

In summary, emissions would be below the thresholds outlined in Utah Administrative Code R307-410-4, would be indistinguishable from background concentrations as measured by regulatory monitors or predicted by models, and would not affect air quality to a degree that a detailed analysis is required.

General Conformity Review

Section 176(c) of the Clean Air Act requires Federal agencies' actions to conform to applicable implementation plans for attaining and maintaining the NAAQS. Federal actions occurring within non-attainment areas are subject to General Conformity Regulations (40 CFR 93.153). The facilities and loadout activities would occur in Carbon County which is designated as

attainment of the NAAQS. However, oil tanker trucks that would transport oil to the Wildcat Loadout Facility would originate within the Uinta Basin 8-hour O_3 Moderate Nonattainment Area (NAA). NAAs are designated by EPA and State regulatory agencies as having monitored criteria pollutant concentrations that exceed the NAAQS.

As stated in Section 3.2, Uinta Basin oil production and transportation of crude oil to or from the Wildcat Facility is outside of the BLM's regulatory authority and control. Direct emissions (40 CFR 93.152) related to this project (i.e., facility construction and operation) would be located outside of the NAA and thus are not subject to the General Conformity Rule. Indirect emissions (40 CFR 93.152) would be limited to vehicle travel on public roads. Vehicle emissions during public travel are not subject to the General Conformity Rule because the BLM does not exercise continuing program responsibility (40 CFR 93.152) over public travel. Further, emissions in the NAA associated with the Wildcat Loadout Facility would occur regardless of the BLM's decision, as CEG2 would expand their facility onto TLA lands to achieve their desired throughput of 100,000 bbls per day in the event BLM were to deny the ROW. Therefore, emissions in the NAA would still "occur in the absence of the Federal action" and would not be "caused by" the federal action (40 CFR 93.152) and are thus not subject to General Conformity. Therefore, General Conformity does not apply to the Proposed Action.

A.2 – AIB-2 (Greenhouse Gas)

How would the proposed facility construction and operation contribute to greenhouse gas emissions?

Greenhouse gases (GHGs) act to contain solar energy loss by trapping longer wave radiation emitted from the Earth's surface and act as a positive radiative forcing component. GHGs may influence the global climate by increasing the amount of solar energy retained by land, water bodies, and the atmosphere. GHGs can have long atmospheric lifetimes, which allows them to become well mixed and uniformly distributed over the entirety of the Earth's surface no matter their point of origin. The buildup of these gases has contributed to the current changing state of the climate equilibrium towards warming.

Further discussion of climate science and predicted impacts as well as the past, present, and reasonably foreseeable GHG emissions associated with BLM's oil and gas actions are included in the 2023 BLM Specialist Report on Annual Greenhouse Gas Emissions and Climate Trends (BLM 2024a) (hereinafter referred to as the Annual GHG Report). This report presents the estimated emissions of greenhouse gases attributable to development and consumption of fossil fuels produced on lands and mineral estate managed by the BLM and is available at https://www.blm.gov/content/ghg/?year=2023.

A discussion of past, current, and projected future GHG impacts are described in Chapters 4, 8, and 9 of the Annual GHG Report. Additional information on current state, national, and global GHG emissions as well as the methodology and parameters for estimating past, present, and reasonably foreseeable GHG emissions is included in the Annual GHG Report (see Chapters 5,6, and 7).

The incremental contribution to global GHGs from a single proposed land management action cannot be accurately translated into its potential global or localized climate effects in the area specific to the action. Currently, global climate models are unable to forecast local or regional effects on resources resulting from a specific subset of emissions. However, there are general projections regarding potential impacts on natural resources and plant and animal species that may be attributed to the accumulation of GHG emissions. In this EA, the BLM uses GHG emissions as a proxy for impacts and provides context with other proxies such as GHG equivalents.

Table A-3 shows the total estimated GHG emissions from fossil fuels at the global, national, state, and county scales over the last five years. Emissions are shown in megatonnes (Mt) per year of carbon dioxide equivalent (CO_2e). Chapter 3 of the Annual GHG Report contains additional information on GHGs and an explanation of CO_2e. State and national energy-related CO_2 emissions include emissions from fossil fuel use across all sectors (residential, commercial, industrial, transportation, and electricity generation) which are released at the location where the fossil fuels are consumed.

Table A-3. Global and U.S. Fossil Fuel GHG Emissions 2018 - 2022 (Mt CO_2e/yr)

Scale	2018	2019	2020	2021	2022
Global (CO_2 only)	37,831.9	37,824.9	35,944.5	38,082.2	38,521.9
U.S.	4989.8	4855.9	4344.9	4,639.1	4699.4
State	60.0	60.4	56.7	61.3	59.4[2]
Carbon County[1]	0.70	0.65	0.50	0.57	0.58

Source: Annual GHG Report, Chap. 5, Table 5-1 (U.S.) and Table 5-2(State). Global emissions (CO_2 only) from the Emissions Database for Global Atmospheric Research (EDGAR)
Mt (megatonne) = 1 million metric tons
NA = Not Available
1 - County level data are from EPA's Facility Level Information on Greenhouse Gases Tool (EPA 2023) - https://ghgdata.epa.gov/ghgp/
2 – State emissions for the 2022 reporting year are retrieved from https://www.epa.gov/ghgemissions/methodology-report-inventory-us-greenhouse-gas-emissions-and-sinks-state-1990-2022

The Proposed Action would lead to emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These GHG emissions would be emitted during construction and operation of the facility. Construction emissions would be temporary (during construction only) and would originate from vehicle travel to and from the project location as well as from heavy construction equipment used to construct the facility. Operation would result in emissions from vehicle travel to and from the project location, unloading and loading activities, oil tanker trucks, railway cars and oil trains, stationary heaters, storage tanks, and a vapor combustion unit. Operational emissions would occur over the entire life of the facility, which is assumed to be 20 years for this analysis based on the estimated life of the project. As stated in section 3.2.1, total mileage that oil haul trucks travel would decrease since the distance to the Wildcat Loadout Facility would be less than the distance to where the oil is currently going (Salt Lake or other refineries). Therefore, GHG emissions from truck traffic related to the Proposed Action would also be

anticipated to decrease. As a conservative estimate, BLM assumed a net-zero change in GHG emissions related to oil hauling truck traffic. Therefore, the emissions presented below are representative of facility construction and operation only.

GHG emissions were calculated based on the maximum throughput of the facility. Maximum facility throughput would be 100,000 bbls per day (per DAQE-AN150710004-24 and limitations on the trucking capacity of Consumer Road). Table A-4 shows the estimated maximum year and life of project GHG emissions for both 100-yr and 20-yr global warming potentials (GWP). Section 3.4 of the Annual GHG Report provides a detailed explanation of GWP.

Table A-4. Estimated GHG Emissions from the Proposed Action on a Maximum year and Life of Project Basis (tonnes)

	CO_2	CH_4	N_2O	CO_2e (100-yr)	CO_2e (20-yr)
Max Year[1]	8,644.54	0.17	0.09	7,868.85	7,876.98
Life of Project	172,890.87	3.40	1.78	157,376.92	157,539.69

1 – Maximum year emissions include GHG emissions from construction and operation of the Wildcat loadout Facility, assuming maximum throughput would be achieved in the first year after construction.

The Environmental Protection Agency (EPA) GHG permitting programs only apply to major stationary sources emitting over 100,000 metric tons (mt) carbon dioxide equivalent (CO_2e) per year (e.g., power plant, landfill, etc.) or modifications of major sources with emission increases greater than 75,000 mt CO_2e per year. Additionally, the EPA requires annual reporting for facilities with stationary sources that emit 25,000 mt CO_2e per year to provide a basis for future policy decisions and regulatory initiatives regarding GHG's. Maximum annual emissions associated with the Proposed Action are estimated to be 7,876.96 mt CO_2e per year and would not trigger EPA rules, permitting, or reporting requirements. Since, emissions associated with the Proposed Action would be below EPA's permitting and reporting thresholds GHGs would not be affected to a degree that a detailed analysis is required.

Past, Present, and Reasonably Foreseeable Trends and Actions

As stated in section 3.2, Uinta Basin oil production, transportation of crude oil from the Martin Yard, and refining and downstream use of the oil are outside of the BLM's regulatory authority and control. GHG emissions from any federal oil that would pass through the facility that are a result of BLM approved actions are included in the emissions presented in the Annual GHG Report.

A.3 – AIB-3 (Cultural Resources)

How would the Proposed Action impact cultural resources in the area of potential effect*?*

Pursuant to Section 106 of the National Historic Preservation Act, its implementing regulations at 36 CFR Part 800, and the State Protocol Agreement Between the Bureau of Land Management and the Utah State Historic Preservation Office Regarding the manner in which the Bureau of Land Management will meet its Responsibilities under the National Historic Preservation Act as provided for in the National Programmatic Agreement (2020), this project is a federal undertaking with the potential to effect historic properties (36 CFR 800.3([a]). Therefore, a Class

III Intensive Field Survey to identify cultural sites and historic properties (National Register of Historic Places-eligible sites) in the area of potential effect was conducted in May of 2023, by PFO archeologist resulting in 4.61 acres of BLM land being inventoried (U23BL0691). This smaller survey was conducted on lands that were not surveyed as part of the 2013 Class III survey. One previously recorded site as eligible for the National Register of Historic Places (NHPA) was revisited and no contributing features were observed. One isolated find was documented and determined not eligible for the NRHP. The BLM has made an undertaking determination of no historic properties affected directly and indirectly (physically, visually, auditorily and atmospherically). As the site has no contributing features and isolated finds are not eligible for the NRHP, there would be no significant impact to cultural resources from this Proposed Action. Due to the project size and finding of effect, the report was sent to SHPO under the Small-Scale Programmatic Agreement and received April 12th, 2024 (Case No. 24-0813).

A.4 – AIB -4 (Native American Concerns)

How would the Proposed Action impact Native American concerns?
Agency staff undertook an analysis of whether tribal consultation would be required or appropriate consistent with Executive Order 13175 and the 2022 Presidential Memorandum on Uniform Standards for Tribal Consultation for this undertaking, which is the modification of the existing Wildcat Loadout ROW. After considering this analysis, the agency official determined there is a reasonable basis that the Proposed Action could have tribal implications, as defined at EO 13175.1[a]. Tribal consultation letters were mailed and emailed on May 8, 2025.
No sacred sites were identified in the area of potential effects. Tribal Nations did not notify the BLM of any sacred sites or Native American ceremonial sites within the area of potential effects and therefore there are no resources available for a detailed analysis. The Paiute Tribe of Utah responded on June 16th, 2025, requesting to participate in the NEPA process. This consultation process is ongoing as of June 17, 2025.

A.5 – AIB-5 (Farmlands (prime/unique))

How would the Proposed Action impact prime and/or unique farmlands within the ROW?
After a Web Soil Survey review (accessed 5/12/25) there are soils rated as Prime if irrigated (48 Haverdad loam and 52 Hernandez family), however irrigation is inconsistent with the 2008 approved PFO RMP which does not permit irrigation on BLM administered lands. In the 2008 PFO RMP, LAR-7 does not allow for agricultural leasing or agricultural entry due to lack of water or access. The rest of the ROW is rated as Not Prime Farmland, and it is not anticipated that this resource requires additional analysis.

A.6 – AIB-6 (Fuels/Fire Management)

How would the Proposed Action impact fire and fuels management and the potential for wildfire within the ROW?

Based on a site visit, implementation of the Proposed Action would not affect Fuels and Fire Management Resources to a degree that further analysis is required, due to the low amount of fuels within the ROW. It is a previously disturbed area void of vegetation, and it would not contribute to fire spread. Therefore, the fuels would not be sufficient in carrying fire. There are no planned fire and fuels management action in the area therefore, the act of the Proposed Action would not inhibit BLM from being able to conduct fire and fuels management.

The potential for fires to ignite from a railway car or oil tanker truck accident is addressed sections 3.4 and 3.5).

A.7 – AIB-7 (Geology/Minerals/Energy Production)

How would the Proposed Action impact geological and mineral resources, and energy production within and adjacent to the ROW?

Under the Proposed Action, the planned additional infrastructure would be located within the existing ROW, so no new impacts are expected. The BLM would retain mineral rights and could still authorize future mineral activity on these lands because they are open to leasing in the 2008 PFO RMP. Lessees may also explore the fluid mineral resources under the leases through use of directional drilling from sites outside the ROW. Moreover, there is only one oil and gas special act ROW lease (UTU-079159) for minerals below the ROW lands, located in T. 13 S., R. 9 E., Sec. 33, SW1/4, the lessee would still have access to these minerals subject to lease stipulations. Therefore, there would be no effect on mineral development associated with that leasehold interest.

With respect to minerals associated with lands outside of the ROW but adjacent to, there would also be no impacts to mineral development because the ROW would not limit access to those minerals. According to the BLM's and Utah Division of Oil, Gas & Mining's GIS data, there is an oil and gas lease (UTU 079159) within the 270-acre ROW and oil and gas leases in adjacent sections south of the ROW. The closest producing well (4300730617) is 0.25 miles south of the ROW. There were a few wells planned to be drilled within the ROW over 20 years ago, but they were not. If there is renewed interest in drilling, further analysis would be done when an APD is received. Therefore, effects to leaseholders in and near the ROW are not considered further in this document.

The Proposed Action is responding to an application seeking to move currently generated Uinta basin crude oil to market. The Proposed Action would not result in or trigger new oil production, which is driven by market demand and world events (EIA 2024b).

A.8 – AIB-8 (Lands/Access)

How would the Proposed Action impact lands and access within the ROW?

Because the Proposed Action is a modification of an existing ROW, it is compatible with existing land uses in the vicinity of the ROW. The BLM reviewed their Mineral & Lands Record System (MLRS) and the Master Title Plats. Other existing ROWs that touch or are in the immediate vicinity of the Wildcat Loadout ROW include CEG2 and the following:

- Utah Rail Company SL-0-015794 rail tracks

- PacifiCorp dba Utah Power and Light UTU-20384 48-kV powerline, and UTU- 53815 switch rack
- Emery Telcom UTU-32293 buried Communication Line
- Carbon County UTU-54688 Consumer Road
- Utah Rail Company has control over traffic it allows on its tracks in its ROW and would not be impacted as a result.

Traffic on Consumers Road is analyzed in section 3.4. Carbon County holds the Consumers Road ROW. It is supportive of the increased traffic that may occur (Communication with Carbon County, 2025). There are no changes anticipated under the alternatives that would lead to a modification in the Carbon County ROW, such as widening or realigning, therefore lands and access is not analyzed in detail.

A.9 – AIB-9 (Livestock Grazing and Rangeland Health Standards)

How would the Proposed Action impact livestock grazing and Rangeland Health Standards within the ROW?
The ROW is within the Consumers Wash Allotment; however, all work will occur within the existing ROW, which is already fenced off to exclude livestock from entering the ROW. No impacts to livestock grazing or Rangeland Health are anticipated because of the existing fence.

A.10 – AIB-10 (Paleontological Resources)

How would the Proposed Action impact paleontological resources within the ROW?
The ROW is Potential Fossil Yield Classification (PFYC) 3 (Mancos Shale), indicating some potential for encountering paleontological resources. Scientifically important paleontological resources are not expected to be disturbed or damaged by the proposed activity because the PFYC 3 geologic units in the area are previously disturbed and paleontological resources in this Member in this area are typically common invertebrates.

A.11 – AIB-11 (Plants: Invasive and Noxious Weeds)

How would the Proposed Action contribute to introduction and spread of invasive species and/or noxious weeds within and adjacent to the ROW?
Surface disturbing activities have the potential to introduce/spread invasive species/noxious weeds. There are invasive species & noxious weeds within the ROW. After a GIS review (accessed 5/12/25) and with local site knowledge, there are several noxious/invasive weeds species present in the ROW or immediately adjacent to it that include, but is not limited to: tamarisk, musk thistle, cheatgrass and Russian thistle. Design Feature 2.2.2.8 is a commitment to monitor, plan and control any additional invasion of noxious and invasive species. If spraying on BLM administered lands, the proponent must submit a Pesticide Use Proposal (PUP) that then must be approved before treatment can occur with BLM approved chemicals. Prevention actions outlined in the 2024 Record of Decision for Vegetation Treatments Using Herbicides on Bureau of Land Management lands in 17 Western States, Programmatic Environmental Impact

Statement (Appendix A) and attached as Design Feature 2.2.2.8. would be followed by the proponent. Equipment used would be washed prior to use to remove mud and debris that may contain invasive or noxious weed seeds and help to reduce the chance of invasive or noxious weed spread. Because of these Design Features, noxious and invasive weeds has not been carried forward for detailed analysis.

A.12 – AIB-12 (Plants: Native Vegetation)

How would the Proposed Action impact native vegetation within the ROW?
Based on site visit and GIS review, the ROW has sparse native vegetation cover due to the Project Location being previously disturbed in the ROW since at least the 1980s. Approximately ninety percent of the vegetation that is present within the ROW is non-native invasive species, approximately five percent is non-native noxious weeds, and approximately five percent is native plants, which occurs along the outer edges of the previously disturbed area. Because of this previous disturbance and lack of native vegetation it is anticipated that native vegetation would be limited in the ROW for the life of the facility. After the life of the facility has concluded, it is expected that reclamation efforts would be implemented to restore native vegetation to appropriate levels following the Green River District (GRD) Reclamation Guidelines. Therefore, native vegetation will not be impacted to a degree that it has been brought forward for detailed analysis.

A.13 – AIB-13 (Recreation)

How would the Proposed Action impact recreation in the ROW and in the immediate area?
The ROW is in an Extensive Recreation Management Area where recreation opportunities, facilities, and needs are limited. Implementation of the ROW would have minimal impact on recreation, because it is within a previously disturbed ROW where there are no recreation sites. The facility is located just off the main paved road, and recreation access beyond this facility to places like Gordon Creek will not be changed. Therefore, detailed analysis is not warranted.

A.14 - AIB-14 (Socioeconomics)

How would the Proposed Action impact employment, labor income and value added in Carbon County?
Construction: There would be short-term economic benefits during construction of the loadout either on the BLM ROW or on the leased TLA lands. Construction is anticipated to take 6-8 months and employ approximately 50 people. Construction would include creating two permanent storage tanks, adding additional rail tracks, truck unloading lanes, unloading racks and railcar loading racks. The inactive coal loading equipment will also be removed as necessary to provide an area for construction. The construction needs would include manual laborers, skilled concrete workers, welders, and track-hoe, back-hoe, grader, crane and dozer operators. According to Headwaters (https://headwaterseconomics.org/tools/blm-profiles/), non-services related jobs like construction account for 17.5% of the total jobs in Carbon County and 15.5% of

the total in the State of Utah. Wildcat could employ these skilled construction workers from anywhere in the State. This is normally based on bids from companies so the workers may not necessarily be from local communities. The state average annual wage for this type of employment is $68,433 (https://jobs.utah.gov/wi/data/library/index.html).

Other Highway users: Under both alternatives, truck travel would increase and lead to an average of approximately 345 truck deliveries. These are freight corridors connecting the Uinta Basin in northeastern Utah to central parts of the state that support the economies within the Uinta Basin and Carbon County. They are also key routes used by oil and gas exploration, recreational users, and commuters. In addition, all three routes are part of Dinosaur Diamond Scenic Byway which provides motorists access to several vistas, wildlife viewing, and mountainous high desert scenery, and connects several prehistoric sites such as Dinosaur National Monument and Jurassic National Monument. Traffic volumes on the highways can affect the condition of the roads, traffic flow, and user experience.

Trucks and Truck Drivers: In 2023, transportation and warehousing employment equaled 77,354, and the annual monthly stable job wage was 5,204 in Utah. The number of separations from employment vs. new hires were both in the 60,000 to 65,000 range (https://jobs.utah.gov/wi/data/library/employment/emptrends.html). According to the US Bureau of Labor statistics employment of heavy and tractor-trailer truck drivers is projected to grow 5 percent from 2023 to 2033, about as fast as the average for all occupations. In the US, about 240,300 openings for heavy and tractor-trailer truck drivers are projected each year, on average, over the decade. Many of those openings are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire[13].

The anticipated number of trucks and truck drivers needed to transport a maximum throughput of 100,000 bbls per day would be approximately 143. This calculation is based on 345 deliveries per day, and that most trucks may deliver 3 times per day. This is an increase of approximately 82 trucks and truck drivers needed. Most of the drivers that are employed currently come from the Uinta Basin or other areas to the north of Carbon County. If these trucks or drivers are not readily available this could lead to a short-term decrease in the amount of bbls/day that could be transloaded. However, Wildcat has had this problem in the past and has been able to remedy it within a few weeks.

Trains: The Wildcat Loadout expansion would increase the number of train cars per day from 48 to 160. This would increase number of trains from one full train (104 cars) every 2.16 days, to one full train every .65 days. Train operators are included in the State of Utah numbers above for transportation and warehousing employment. According to the US Bureau of Labor Statistics, employment of railroad workers in the US is projected to grow 2 percent from 2023 to 2033, slower than the average for all occupations. Despite limited employment growth, about 7,300 openings for railroad workers are projected each year, on average, over the decade. Most of those openings are expected to result from the need to replace workers who transfer to different occupations or exit the labor force, such as to retire. The median annual wage for railroad

[13] *https://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm#:~:text=in%20May%202024.-,Job%20Outlook,on%20average%2C%20over%20the%20decade*

workers was $75,680 in May 2024. According to https://www.aar.org/issue/crew-size/ the average crew size for a train is two people. They also state that it is becoming more common to see a crew of one. The increase in trains might create employment for one more person when they reach maximum throughput.

Trains are a significant part of the global economy and a critical pillar of the US economy. In the US, rail transportation contributes approximately 233 billion in total economic output, 66 billion in total household income, 25 billion in annual tax revenues, supporting federal, state, and local government budgets, and 26 billion in annual reinvestments. Utah is included in these numbers but is not one of the top 5 states that make up 34% of this contribution. The societal benefits of freight rail further demonstrate its critical role in economic sustainability, environmental efficiency, and infrastructure optimization. By reducing fuel consumption, greenhouse gas emissions, highway congestion, and public infrastructure costs, rail transportation enhances the resilience and sustainability of the U.S. freight network (https://www.aar.org/wp-content/uploads/2025/02/AAR-PE-Economic-Impact-Report-2025-FINAL.pdf). [1]

CEG2 would further develop its transloading facilities under either alternative so the impacts are expected to be the same. Any impacts to socioeconomics would not be concentrated in Carbon County but instead spread across multiple counties or the whole state of Utah. The employment, labor income and value added would not lead to a shift in the social or economic landscape in Carbon County therefore socioeconomics has not been brought forward for detailed analysis.

A.15 - AIB-15 (Soils (Physical/Biological))

How would the Proposed Action impact physical and biological soils within the ROW?
After a Web Soil Survey review (accessed 5/12/25) the dominant soils types in the ROW are 29: Dumps, mine, 48: Haverdad loam, 52: Hernandex family and 113 Strych very stony loam. These soils are rated from slight to moderate for Erosion Hazard (Road, Trail) Some soils are not rated for Soil Restoration Potential, but those that are mapped have either Moderate or High Soil Restoration Potential ratings. Additional disturbance within the already disturbed area could increase erosion. Based on site analysis, the Plan of Development contains site grading processes to minimize erosion (section 2.2.1). Because this site has been disturbed for over 40 years, and is within the existing ROW with active disturbance, it is anticipated that soil health and function would be limited in the ROW for the life of the facility. However, after the life of the facility has concluded, it is expected that reclamation efforts would be implemented to restore native vegetation to appropriate levels following the Green River Districts (GRD) Reclamation Guidelines. Therefore, it is not anticipated that impacts to this resource require a detailed analysis.

There are no biological soils within the ROW because the area has been previously disturbed.

A.16 – AIB-16 (Visual Resources)

How would the Proposed Action impact visual resources within the ROW?
The ROW is within a VRM Class 3 area. Class 3 objectives are to partially retain the existing character of the landscape, with a moderate level of change allowed. With design features to make the facilities Covert Green, the new development in an already-built area would not change the visual contrast and would meet the standards of VRM Class 3 managements. Therefore, detailed analysis is not warranted.

A.17 – AIB-17 (Wastes (hazardous and solid))

How would the Proposed Action contribute to hazardous and solid wastes within the ROW?
OPM's Process Safety Management (PSM) standard and Risk Management Program (RMP) regulations do not apply because the flammable liquids are exempted or excluded as they will be stored only incident to transportation.

Safety Data Sheets (SDS) or a list of hazardous chemicals must be submitted to State or Tribal Emergency Response Commission (SERC or TERC), Local or Tribal Emergency Planning Committee (LEPC or TEPC), and the local fire department for chemicals or materials in volumes subject to reporting under the Superfund Amendments and Reauthorization Act (SARA) Title III, that required Safety Data Sheets (SDS). An annual inventory of these chemicals must also be submitted by March 1 of each year to their State or Tribal Emergency Response Commission (SERC or TERC), Local or Tribal Emergency Planning Committee (LEPC or TEPC), and local fire department. The information submitted by facilities must be made available to the public. The potential impacts resulting from a spill and mitigation to prevent the spill from being released into the environment will be addressed in the facilities Spill Prevention and Countermeasures Plan (SPCC). The Resource Conservation and Recovery Act (RCRA) may be triggered in the event of a spill. Because the Wildcat Loadout Facility maintains SDS onsite and maintains a SPCC plan, both of which provide measures to prevent spills, respond to spills, and mitigate spills, this resource was dismissed from detailed analysis.

A.18 – AIB-18 (Water: Groundwater Quality)

How would the Proposed Action impact groundwater quality within or near the ROW?
According to GIS review, there are no protected groundwater sources in the area. The nearest one is approximately 9.5 linear miles northwest.

The Proposed Action would occur on approximately 30- acres of previously disturbed land within a 270-acre ROW that are already disturbed and have a water runoff system in place. Distance to protected sources, project design, existing systems, and the Design Features in section 2.2.2, 2.2.2.4, 2.2.2.6, and 2.2.2.7 avoid or mitigate impacts to these resources lower in the watershed. So, there is no potential for impacts that warrant detailed analysis.

A.19 – AIB-19 (Water: Hydrologic Conditions (stormwater))

How would the Proposed Action impact hydrologic conditions within or near the ROW?

Per GIS data review and local knowledge, the nearest major body of water is the Price River, which is located approximately 2.5 miles east of the ROW.

The Proposed Action would be on approximately 30- acres of previously disturbed land within a 270-acre ROW that have a water runoff system in place (section 2.1.1). Improvements to the water runoff system are proposed in section 2.2.2 and include regrading the site, filling in a sediment pond, extending a second sediment pond, and moving a culvert to accommodate the new truck traffic pattern inside the ROW. The improvements also include drainage ditches to collect runoff from areas on the northeast end of the facility and divert storm water runoff into a sediment pond.

The SPCC plan (section 2.2.2.4) with its required staff trainings and Storm Water Pollution Prevention Plan (as required by the site's UPDES permit) (section 2.2.2.7), would help control erosion and sediment by diverting runoff within the facility to sediment ponds. Because of distance to Price River, site design, and permit requirements, stormwater runoff would not have a potential for impacts that warrant detailed analysis.

The existing rail between the Wildcat Loadout Facility and the Martin Yard crosses an ephemeral wash. The intersection between Consumers Road and Highway 6 is 0.1 mile west of the Price River. Effects from railway car and oil tanker truck spills are addressed sections 3.4 and 3.5.

A.20 – AIB-20 (Water: Municipal Watershed / Drinking Water Source Protection)

How would the Proposed Action impact municipal watersheds and drinking water resources within or near the ROW?

Per GIS review, there are no protected groundwater sources in the area. The nearest one is approximately 9.5 linear miles Northwest.

The ROW would occur within a Surface Source Protection Zone 4, as defined in https://documents.deq.utah.gov/drinking-water/rules/DDW-2018-003500.pdf, which means it is furthest from the source zone (the Price River Intake) that is used for municipal water and is approximately 1.5 to 2 linear miles from zone 3 respectively north, east and south of the ROW boundary.

The Proposed Action would be on approximately 30- acres of previously disturbed land within a 270-acre ROW that has a water runoff system in place. Distance to protected sources, project design, existing systems, and the Design Features in section 2.2.2, 2.2.2.4, 2.2.2.6 and 2.2.2.7 avoid or mitigate impacts to these resources lower in the watershed. Therefore, there are no impacts anticipated that warrant detailed analysis.

A.21 – AIB-21 (Water: Streams, Riparian, Wetlands, Floodplains)

How would the Proposed Action impact streams, riparian areas, wetlands and floodplains within or near the ROW?

None of these resources are within the 270-acre ROW per review of GIS aerial imagery and GIS database review. The nearest streams, riparian, wetlands, and floodplains are along the Price River located approximately 2.5 linear miles to the east of the ROW.

The Proposed Action would be on approximately 30- acres of previously disturbed land that have a water runoff system in place. Dust and erosion at the site is controlled by magnesium chloride treatments as well as an existing water runoff system that captures and contains storm water. Changes to the water runoff system are proposed in section 2.2.2 to accommodate the new truck traffic pattern. Distance to protected sources, project design, existing systems, and the Design Features in section 2.2.2, 2.2.2.4, 2.2.2,6 and 2.2.2.7 avoid or mitigate impacts to these resources lower in the watershed. Therefore, potential for impacts does not warrant detailed analysis.

The existing rail between the Wildcat Loadout Facility and the Martin Yard crosses an ephemeral wash. The intersection between Consumers Road and Highway 6 is 0.1 mile west of the Price River. Effects from railway car and oil tanker truck spills are addressed sections 3.4 and 3.5.

A.22 – AIB-22 (Water: Surface Water Quality)

How would the Proposed Action impact surface water quality within or near the ROW?
Within the 270-acre ROW, per GIS aerial and GIS data, the surface water that would occur would primarily be during precipitation events. See also the Stream section above.
The Proposed Action would be on approximately 30- acres of previously disturbed land that have a water runoff system in place (section 2.2.2). Dust and erosion at the site is controlled by magnesium chloride treatments as well as an existing water runoff system that captures and contains storm water. Changes to the water runoff system are proposed in section 2.2.2 to accommodate the new truck traffic pattern.

The SPCC plan (section 2.2.2.4) with its required staff trainings and Storm Water Pollution Prevention Plan (as required by the site's UPDES permit) (section 2.2.2.7), would help control erosion and sediment by diverting runoff within the facility to sediment ponds. Because of distance to Price River, site design, and permit requirements, stormwater runoff was dismissed from detailed analysis.

The existing rail between the Wildcat Loadout Facility and the Martin Yard crosses an ephemeral wash. The intersection between Consumers Road and Highway 6 is 0.1 mile west of the Price River. Effects from railway car and oil tanker truck spills are addressed sections 3.4 and 3.5.

A.23 – AIB-23 (Wildlife: Migratory Birds including Raptors)

How would the Proposed Action impact migratory birds including raptors within the ROW and within a one-mile buffer?

There is no RMP designated migratory bird nesting habitat within the ROW. Although migratory birds may occur within the ROW, the area is already disturbed and is actively in use for loadout operations. These elements would discourage current and future nesting activities in the ROW. Raptor nests are known to occur a mile away on the cliffs outside of the ROW. Considering the lack of migratory bird habitat, distance to known nests, and the Design Features (section 2.2.2.9) migratory birds and raptors were dismissed from further analysis.

However, vehicle strikes and noise and light impacts from traffic and trains are addressed sections 3.4 and 3.5).

A.24 – AIB-24 (Wildlife: Fish (Designated or Non-designated))

How would the Proposed Action impact fish within the Green River watershed?
Per GIS review there are no known populations of threatened or endangered fish species or any known habitat within the ROW. The ROW is in the greater Green River watershed and ROW modification surface disturbing activities could have impacts on waterways that lead into critical habitat on the Green River. Section 2.2.2.4 outlines a Spill Prevention, Control, and Countermeasures that would reduce the likelihood a contaminant would end up in waterways that connect to critical habitats. Given the lack of populations in the ROW, and the Spill Prevention, Control, and Countermeasure plan to handle contaminates, there would be no potential impact to threatened and endangered fish or BLM sensitive fish species that would require detailed analysis.

The existing rail between the Wildcat Loadout Facility and the Martin Yard crosses an ephemeral wash. The intersection between Consumers Road and Highway 6 is 0.1 mile west of the Price River. Effects from railway car and oil tanker truck spills are addressed sections 3.4 and 3.5.

A.25 – AIB-25 (Wildlife: Non-USFWS Designated)

How would the Proposed Action impact non-USFWS designated wildlife within the ROW, along Consumers Road, and along the Wildcat Loadout Facility to Martin Yard railway
Per GIS review:
Elk: The ROW is within the 241,770-acre crucial winter elk habitat. The ROW is on the far east border of the defined crucial winter elk habitat. Consumers Road is not within the crucial winter habitat. Since the ROW already exists, it is anticipated there would be no impact to elk habitat that would require detailed analysis.

Deer: The ROW is within an about 40,000-acre crucial winter deer habitat unit named Wasatch-Manti. Gordon Creek Wildlife Management Area is 1.2 miles from the ROW. Gordon Creek is known to hold many mule deer during the winter due to its crucial winter habitat for deer. Since mule deer population trends listed in the Utah Mule Deer Statewide Management Plan from 2013-2018 timeframe has consistently trended in a positive increase, detailed analysis is not needed.

However, vehicle strikes and noise and light impacts from traffic and trains are addressed sections 3.4 and 3.5).

A.26 – AIB-26 (Wildlife: Threatened, Endangered, Proposed or Candidate)

How would the Proposed Action impact threatened, endangered, proposed or candidate wildlife species within the ROW and a ¼ or ½ mile buffer?

IPAC (USFWS's Information for Planning and Consultation website https://ipac.ecosphere.fws.gov/) shows Mexican Spotted, Yellow-billed Cuckoo, Suckely's cuckoo bumble bee, and monarch butterfly as the species that could potentially occur within ½ mile of the ROW. Following an on the ground assessment by BLM biologists multiple times during 2023 and 2024, Mexican Spotted Owl, Yellow-billed Cuckoo, and Suckley's cuckoo bumble bee are not present because and they do not have suitable habitat or known occupied locations within the ROW and the immediate surrounding area. Therefore, there is no known effect to these species. Monarch butterfly has the potential to occur within the ROW where milkweed plants are found. Based on site visits, there are no milkweed plants or pollinating plants that this species would use so there is no jeopardy to the monarch butterfly.

According to USGS CONUS habitat models, Golden Eagle, kit fox, Townsend's big-eared bat, spotted bat, great plains toad all have potentially suitable habitat within the ROW. A site visit determined that there is no habitat for these species within the ROW due to the site being previously disturbed, however there may be adequate habitat nearby that these species use.

Greater Sage-Grouse (GRSG):
According to the applicable Utah Greater Sage-grouse (GRSG) Approved RMP Amendment (2015 ARMPA) (BLM 2015), the entire 270-acre ROW for the Wildcat Loadout Facility occurs in a General Habitat Management Area (GHMA). GHMA are BLM-administered lands where some special management will apply to sustain Greater Sage-grouse populations, areas of occupied seasonal or year-round habitat outside of Priority Habitat Management Areas. Specifically, the ROW and surrounding GHMA is categorized as winter habitat per the Utah State University Kohl Model.[14] This habitat may provide connectivity with summer/nesting/winter habitat in Porphyry Bench, over three miles to the west. There are approximately 29,000,000 acres of GHMA identified in the State of Utah. Table A.-5 shows acres and miles of lands the Proposed Action would potentially impact within GHMA.

[14] *https://gis.blm.gov/utarcgis/rest/services/Wildlife/BLM_UT_GRSG_Seasonal_Habitats_Polygons/FeatureServer*

Table A-5: Lands Potentially Impacted Within GHMA

Lands potentially impacted within GHMA	Acres
Proposed Action	30 acres on previously disturbed lands
Already disturbed lands within the ROW	75 acres
Consumers Road on TLA lands	2 miles
Consumers Road on BLM outside of ROW	Less than $1/10^{th}$ of a mile
Railway to Martin Yard	1 mile

PFO biologists conducted a site visit in 2023 to the ROW and the adjacent lands (1/4-mile buffer) to the ROW. They chose this analysis area because there was no buffer identified in the ARMPA for GHMA, and it only specified occupied habitat, of which the closest occupied lek is over 18 miles to the north in the Emma Park Area. The biologists categorized the habitat within the ROW and buffer as previously disturbed or degraded and unsuitable because it is missing sage brush, forbs, and wet meadows which are habitat needs for Greater Sage-grouse either permanently or seasonally according to Table 2-2 in the ARMPA. For winter habitat there needs to be sagebrush greater than 10% of vegetative cover and greater than 10 inches in height for cover and food (BLM 2015). This necessary habitat was not present within the analysis area because of previous disturbance and previous and current grazing activities.

Based on observations and historical data, there are zero leks within this ROW and the surrounding area. Additionally, according to Utah Division of Wildlife Resources wildlife tracking data from GPS-radio collars on individual GRSG, there has not been any occurrences of GRSG within 5 miles of the 270-acre ROW. Because of this absence of GRSG at the existing Wildcat Loadout Facility, Consumers Road, and rail ROW between Wildcat Loadout Facility and Martin Yard impacts to GRSG are unlikely to occur.

The Proposed Action does include installation of tanks that are tall structures. For tall structures, the buffer distance in Appendix B of the 2015 ARMPA is within 2-miles of leks and for noise at least 0.25 miles from leks; there are no occupied leks within proximity to the ROW, the nearest lek is over 18 miles away.

The Proposed Action would place infrastructure in already disturbed locations and will incorporate the Design Feature (section 2.2.2.9) to equip tanks and other above-ground facilities with structures or devices that discourage nesting by raptors or corvids, which prey upon sage-grouse. Because of the lack of suitable habitat, lack of documented individuals and populations, and incorporation of design features to minimize any potential impacts, detailed analysis is not needed.

Animal strikes and noise and light impacts from traffic and trains are addressed sections 3.4 and 3.5).

B. APPENDIX B – UINTA BASIN PRODUCTION AND EXPORT CAPACITY

Utah Crude Oil Production and Uinta Basin Crude Oil Pricing

In Utah, oil drilling operations and producing wells are concentrated in the Uinta Basin in northeastern Utah and the Paradox Basin of southeastern Utah. Utah's crude oil production declined in 2020 following the drop in petroleum demand and oil prices during the COVID-19 pandemic. Production bottomed out at 69,600 barrels per day in May 2020, but steadily increased and then surpassed pre-pandemic levels in 2021 and 2022, hitting a record high of 136,500 barrels per day in October 2022. The state's crude oil production recovered and in 2023 reached a new high of 56 million bbls (approximately 153,000 bbls per day), a 24% increase from 2022 (57% higher than 2021), mostly attributable to drilling of the oil-rich Green River Formation in the Uinta Basin with new horizontal drilling (2-mile-long laterals) and advanced hydraulic fracturing techniques, leading to a new record-highs (EIA 2024). As of February of 2025, crude oil production in the State of Utah reached 182,000 bbls per day or approximately 66 million bbls per year (EIA 2024). With the growth in production, estimated exports of Utah crude oil nearly doubled to 12.3 million barrels (in 2022), mostly related to more Uinta Basin crude oil heading to the Gulf Coast via trains that are loaded in Carbon County.

Uinta Basin crude oil has historically sold at a discount to the national benchmark, West Texas Intermediate (WTI); in 2022 and 2023 this discount was 13%. This lower price was the result of the waxy nature of the basin’s oil which requires heating and special treatment in refining, the transportation distance, and the market being limited to Salt Lake City refineries. However, currently, about 30%–40% of Uinta Basin waxy crude gets transported to the Gulf Coast via train and can sometimes command a premium price compared to WTI because of its preferential properties. (EIA 2024).

Salt Lake City Refinery Capacity:

Utah's five oil refineries, all located in the Salt Lake City area, process about 207,000 barrels of crude oil per calendar day (208,714 as of May 15, 2025, EIA 2024). Much of the oil processed by the refineries arrives by pipeline from Utah, Colorado, Wyoming, and Canada. Pipelines carry refined products from the refineries to markets in Utah, Idaho, Nevada, Wyoming, eastern Washington, and Oregon. The five oil refineries are not all equipped to handle Uinta Basin waxy crude oils which may be processed into high value refined products, but the refineries that run it need relatively sophisticated (higher complexity) processing equipment in order to extract that potential (SCIC 2017). This limits the refining capacity of the waxy crude oil to 80,000 bbls per day in the SLC refineries.

Carbon County Transloading Capacity:

Beginning in 2013, to respond to production and the lack of refining capacity, three transloading sites began transferring crude oil from trucks to railway cars. Crude oil is trucked to the transload sites from numerous oil wells, some in central Utah and the majority in the Uinta Basin. The crude oil transloaded to train cars on Utah Railway (Utah Rails) and then is transported to Gulf Coast refineries which have the capacity needed to process the waxy crude. The existing, proposed, and approved transloading sites are as follows:

- The existing Price River Terminal (the former Wellington Coal Wash Plant) is currently permitted by Utah State Department of Air Quality to transload 120,000 bbls a day through storage tanks, and 10,000 bbls transloading through mobile operations (truck to railcar)[15].
- The existing Savage Terminal (formerly C.V. Spur) is currently permitted by Utah State Department of Air Quality to transload 30,000 bbls per day[16]. The Utah State Department of Air Quality approved their request to increase their daily thruput to 80,000 bbls per day[17].
- The existing Wildcat Loadout currently transloads 20,000 bbls per day. The Utah State Department of Air Quality approved their request to increase daily thruput to 100,000 bbls per day.
- The approved Utah Candle Company, LLC facility being constructed on TLA lands near the existing Wildcat Loadout Facility will have 80,000 bbls per day capacity if the Wildcat Loadout's ROW modification request is denied by the BLM. The company has broken ground at the alternate location but has not yet installed equipment.
- The proposed UB Railway's NEPA was recently upheld by the Supreme Court, clearing the way for Surface Transportation Board, Forest Service and Bureau of Indian Affairs to reissue to permits[18]. It is anticipated to transport crude oil volumes ranging from 130,000 to 350,000 barrels per day. This facility is not yet constructed.

This makes the current transloading capacity within Carbon County 180,000 bbls per day, with additional capacity approved and additional facilities pending. It is unknown how many bbls per day each of the transloading facilities are actually transloading.

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15 *https://daqpermitting.utah.gov/DocViewer?IntDocID=154025&contentType=application/pdf#:~:text=The%20storage%20tank%20has%20a,transloaded%20through%20mobile%20operations%20daily.&text=The%20emissions%20listed%20below%20are,rounding%20of%20emissions%20is%20possible.&text=II.,noted%20for%20informational%20purposes%20only*

16 *https://daqpermitting.utah.gov/NOI_Pub_H*

17 *https://daqpermitting.utah.gov/NOI_Pub_H*

18 *https://uintabasinrailway.com/docs/Supreme_Court_Clears_Path_for_Uinta_Basin_Railway.pdf*

EXHIBIT 52

DRAFT 1-23-2023

SEVEN COUNTY INFRASTRUCTURE COALITION, UTAH
INDUCEMENT RESOLUTION
PRIVATE ACTIVITY BONDS

February 9, 2023

RESOLUTION NO. 2023-02A

RESOLUTION AUTHORIZING AND INDUCING THE EXECUTION OF A MEMORANDUM OF INDUCEMENT AGREEMENT WITH UINTA BASIN RAILWAY, LLC, OR ANY AFFILIATE ENTITY THEREOF REGARDING THE ISSUANCE OF PRIVATE ACTIVITY BONDS IN AN AMOUNT NOT EXCEEDING $1,900,000,000 TO FINANCE RAIL SURFACE TRANSPORTATION AND FREIGHT TRANSFER FACILITY AND RELATED IMPROVEMENTS; PROVIDING FOR THE PUBLICATION OF A NOTICE OF PUBLIC HEARING AND BONDS TO BE ISSUED; AND RELATED MATTERS.

WHEREAS, Seven County Infrastructure Coalition, Utah (the "Issuer"), is a separate and independent political subdivision authorized and created under the Utah Interlocal Cooperation Act, Title 11, Chapter 13, Utah Code Annotated 1953, as amended (the "Interlocal Act") pursuant to resolutions of each of its member counties consisting of Carbon, Daggett, Duchesne, Emery, San Juan, Sevier, and Uintah counties approving an Interlocal Agreement dated as of and effective as of December 1, 2016 (the "Interlocal Agreement"); and

WHEREAS, pursuant to paragraph 6.1.F of the Interlocal Agreement and as noted in the authorizing or approving resolutions of each member county, the Issuer is authorized to borrow money and incur indebtedness and to issue bonds for the purposes of the Issuer, including a rail surface transportation and freight transfer facilities project; and

WHEREAS, the Issuer, as authorized by its member counties through the Interlocal Agreement, is authorized and empowered by the provisions of the Utah Industrial Facilities and Development Act, Title 11, Chapter 17, Utah Code Annotated 1953, as amended (the "Act") to issue revenue bonds or other forms of revenue financing (the "Bonds") for the purpose of acquiring or financing projects for a facility or improvement, such as rail for any business purpose and for economic development; and

WHEREAS, the Issuer has previously entered into agreements with Drexel Hamilton Infrastructure Partners, L.P. to finance, own, construct, operate and maintain rail facilities, including freight transfer facilities, subject to compliance with certain terms and conditions set forth therein; and

WHEREAS, Drexel Hamilton Infrastructure Partners, L.P. desire to induce the Issuer to sponsor and issue limited obligation bonds to help fund the rail surface

transportation and freight transfer facilities project and related improvements in an amount of not less than $1,900,000,000; and

WHEREAS, in order to enhance economic development and promote commerce and develop trade by inducing commercial enterprises to locate in, develop in, or remain in the State of Utah and the Seven County Infrastructure Coalition, the Issuer desires to help finance the acquisition, or construction, and equipping of a rail surface transportation and freight transfer facilities and related improvements, generally described in Exhibit "C" attached hereto (the "Project"). The Project will be owned and operated in whole or in part by the Uinta Basin Railway, LLC, a Delaware Limited Liability Company, which is owned and controlled by Drexel Hamilton Infrastructure Partners, L.P., a Delaware Limited Partnership, or any affiliate entity thereof (the "Borrower"); and

WHEREAS, the Borrower is reluctant to take steps toward the construction of the Project without satisfactory assurance from the Issuer that the proceeds of the sale of the Bonds of the Issuer will be made available to finance the acquisition, construction, and equipping of the Project; and

WHEREAS, it is deemed necessary and advisable for the development, welfare and prosperity of the Issuer and its inhabitants that the Project be acquired and constructed, and that the Issuer take such action as may be required under applicable statutory provisions to authorize and issue its Bonds to finance the Project in an amount not exceeding $1,900,000,000; and

WHEREAS, the Bonds shall be limited obligations of the Issuer and at no time will they constitute a pledge of the general taxing powers or credit of the Issuer, of any member county, or of the State of Utah; and

WHEREAS, a form of agreement, hereafter designated as a "Memorandum of Inducement Agreement," has been prepared under which the Borrower has stated its willingness to promptly acquire and construct the Project; and

WHEREAS, it is considered necessary and desirable and for the best interest of said Issuer that execution of said Memorandum of Agreement be authorized for and on behalf of the Issuer; and

WHEREAS, the Act provides for the publication of a Notice of Bonds to be Issued, and the Issuer desires to publish such a notice at this time in compliance with the Act with respect to the Bonds:

NOW, THEREFORE, Be It Resolved by the Governing Board of Seven County Infrastructure Coalition, Utah (the "Governing Board"), as follows:

Section 1. In order to assure that the Borrower finance, construct, operate and maintain the Project with the resulting public benefits which will flow therefrom, including economic development, it is deemed necessary and advisable that the

Memorandum of Inducement Agreement hereinafter referred to, be approved and executed for and on behalf of the Issuer.

Section 2. The Memorandum of Inducement Agreement by and between the Borrower and the Issuer in substantially the form and with the contents set forth in Exhibit "B" attached hereto, is hereby approved and the execution thereof is hereby authorized. The Executive Director of the Issuer is authorized to sign the Memorandum of Inducement Agreement with such corrections, changes and amendments as the Executive Director deems necessary or desirable and the application of the signature of the Executive Director shall be conclusive evidence that the Issuer has accepted and agreed to such corrections, changes and amendments. The Issuer's Secretary is authorized to attest to the signature of the Executive Director and to apply the seal of the Issuer to the Memorandum of Inducement Agreement.

Section 3. In accordance with the provisions of the Act, the Secretary shall cause the following "Notice of Public Hearing and Bonds to be Issued" to be published one (1) time in the Deseret News, a newspaper of general circulation in the Issuer, and shall cause a copy of this Resolution (together with all exhibits hereto) to be kept on file in the Secretary's office, for public examination during the regular business hours of the Governing Board until at least thirty (30) days from and after the date of publication thereof. The "Notice of Public Hearing and Bonds to be Issued" shall be in substantially the following form:

NOTICE OF PUBLIC HEARING AND BONDS TO BE ISSUED

NOTICE IS HEREBY GIVEN pursuant to the provisions of the Utah Industrial Facilities and Development Act, Title 11, Chapter 17, Utah Code Annotated 1953, as amended, that on February 9, 2023, the Governing Board (the "Governing Board") of Seven County Infrastructure Coalition, Utah (the "Issuer") adopted an inducement resolution (the "Resolution") in which it expressed its intent to issue Private Activity Bonds in the aggregate principal amount of not to exceed One Billion Nine Hundred Million Dollars ($1,900,000,000) (the "Bonds") to finance the acquisition, or construction, and equipping of a rail surface transportation and freight transfer facilities, and related improvements (the "Project"). The Project will be owned and operated in whole or in part by Uintah Basin Railway, LLC, or any affiliate entity thereof (the "Borrower").

NOTICE IS FURTHER GIVEN that the Issuer hereby calls a public hearing with respect to the Bonds on March 9, 2023, at 10:00 a.m. in Room 450 at the State Capitol located at 350 State Street in Salt Lake City, Utah. The Borrower intends to finance, acquire, and construct rail surface transportation facility and related improvements of approximately 87 miles in length from the Kyune, Utah area near Soldier Summit in Utah County to the Uinta Basin, including freight transfer facilities (the "Project"). This Project involves the financing, acquisition and construction of the rail and related improvements. All members of the public are invited to attend and participate in person or by written comment.

The Bonds are to be issued pursuant to the Resolution and a Final Bond Resolution which authorizes an Indenture of Trust or similarly related document (collectively, "Final Bond Resolution") to be adopted authorizing and confirming the sale of the Bonds for the purpose of financing the Project, establishing associated funds, and paying issuance expenses to be incurred in connection with the issuance and sale of the Bonds.

The Bonds are to be issued and sold by the Issuer pursuant to the Resolution, including as part of said Resolution the draft of a Final Bond Resolution which was before the Governing Board and attached to the Resolution in substantially final form at the time of the adoption of the Resolution (collectively, the "Bond Resolution") and said Final Bond Resolution is to be adopted by the Governing Board in such form and with such changes thereto as shall be approved by the Governing Board upon the adoption thereof. The proposed Bonds will not constitute general obligations of the Issuer, any of its member counties, of the State of Utah or any public body. The Issuer will not be obligated to pay costs incurred in connection with the issuance of the Bonds nor will it be liable to make payments of interest or principal on the Bonds.

A copy of the Resolution and the Final Bond Resolution are on file in the office of the Secretary of the Issuer at 751 E., 100 N., Price, Utah which is the office of the Carbon County Clerk/Auditor, where they may be examined during regular business hours of the Carbon County Clerk/Auditor and Secretary from 8:00 a.m. to 5:00 p.m. for a period of at least thirty (30) days from and after the date of publication of this notice.

NOTICE IS FURTHER GIVEN that a period of thirty (30) days from and after the date of the publication of this notice is provided by law during which any person in interest shall have the right to contest the legality of the Bond Resolution or the Bonds, or any provision made for the security and payment of the Bonds, and that after such time, other than referendum rights, no one shall have any cause of action to contest the regularity, formality or legality thereof for any cause whatsoever. This public hearing is required by the Tax Reform Act of 1986. Comments at the public hearing are invited. Written comments may be submitted to the Issuer to its Secretary at the office of the Carbon County Clerk/Auditor at 751 E. 100 N. in Price, Utah. Additional information can be obtained from the Issuer by calling (801) 520-5333.

DATED February 9, 2023.

/s/ Lenise Peterman
Secretary

Section 4. The Governing Board hereby directs the officials and staff of the Issuer to cooperate with and assist the Issuer's bond counsel, Eric Todd Johnson of Johnson, Patterson and Yellowhorse, and associated professionals to prepare documents and other certificates and opinions reasonably necessary to issue the Bonds.

Section 5. The Issuer hereby declares its intention and it reasonably expects to reimburse expenditures with bond proceeds in accordance with Treasury Regulation § 1.150-2.

Section 6. All resolutions and parts thereof in conflict herewith are hereby repealed to the extent of such conflict.

Section 7. The Governing Board directs the Secretary to complete the attached Record of Proceedings.

Section 8. The Governing Board considers that this resolution is necessary and in the best interest of the Issuer, and therefore, it shall become effective immediately upon its passage, approval and adoption.

Passed and approved this February 9, 2023, by the Governing Board of Seven County Infrastructure Coalition, Utah.

SEVEN COUNTY INFRASTRUCTURE
COALITION, UTAH

CHAIR

ATTEST:

Secretary

(SEAL)



EXHIBIT A
RECORD OF PROCEEDINGS

The Governing Board of the Issuer met in public session at the Governing Board's special meeting place at Room 450 in the State Capitol at 350 State Street, Salt Lake City, Utah on February 9, 2023 (the "Meeting"), at the hour of 10:00 a.m., or as soon thereafter as feasible, with the following members of the Governing Board being present:

Greg Miles	Co-Chair - Duchesne
Casey Hopes	Co-Chair - Carbon
Jack Lytle	Board member - Daggett
Brad Horrocks	Board member – Uintah
Lynn Sitterud	Board member – Emery
Silvia Stubbs	Board member – San Juan
Greg Jensen	Board member - Sevier

Also present:

Keith Heaton	Executive Director
Lenise Peterman	Secretary

Absent:

which constituted all the members thereof.

After the Meeting had been duly called to order and after other matters were discussed, the foregoing resolution (the "Resolution") was introduced in written form and fully discussed.

A motion to adopt the Resolution was then duly made by Horrocks and seconded by Jensen, and the Resolution was put to a vote and carried, the vote being as follows:

VOTING:		
	Carbon	Yea ✓ Nay ___
	Daggett	Yea ___ Nay ___
	Duchesne	Yea ✓ Nay ___
	Emery	Yea ✓ Nay ___
	Sevier	Yea ✓ Nay ___
	San Juan	Yea ✓ Nay ___
	Uintah	Yea ✓ Nay ___

Those Abstaining: Daggett County

Other business not pertinent to the Resolution appears in the minutes of the Meeting. Upon the conclusion of all business on the Agenda and motion duly made and carried, the Meeting was adjourned.

CERTIFICATE OF COUNTY CLERK/AUDITOR

I, Lenise Peterman, the duly appointed and qualified Secretary of the Issuer, do hereby certify that the attached Resolution is a true, accurate and complete copy thereof as adopted by the Governing Board at a public meeting duly held on February 9, 2023 (the "Meeting"). The persons present and the result of the vote taken at the Meeting are all as shown above. The Resolution, with all exhibits attached, was deposited at the office of the Carbon County Clerk/Auditor at 751 E. 100 N., in Price, Utah, on February 9, 2023 and is officially of record in my possession.

I further certify that, pursuant to the Resolution, I caused to be published a "Notice of Public Hearing and Bonds to be Issued" one (1) time in the Deseret News a newspaper having general circulation in the Issuer. An affidavit of publication of such notice shall be attached hereto.

IN WITNESS WHEREOF, I have hereunto subscribed my signature and impressed hereon the official seal of the Issuer, this February 9, 2023.

(SEAL)



Secretary

(ATTACH AFFIDAVIT OF PUBLICATION OF PUBLIC HEARING AND NOTICE OF INTENT TO ISSUE BONDS)

DRAFT 1-23-2023

CERTIFICATE OF COMPLIANCE WITH
OPEN MEETING LAW

I, Lenise Peterman, the undersigned Secretary of the Issuer do hereby certify, according to the records of the Issuer in my official possession, and upon my own knowledge and belief, that in accordance with the requirements of Section 52-4-6(2), Utah Code Annotated, 1953, as amended, I gave not less than twenty-four (24) hours public notice of the agenda, date, time and place of the February 9, 2023 public meeting held by the governing body of the Issuer as follows:

(a) By causing a notice, in the form attached hereto as Schedule 1 (the "Meeting Notice"), to be posted at the principal office of the Issuer at least 24 hours prior to convening the meeting, the Meeting Notice having continuously remained so posted and available for public inspection until the completion of the meeting; and

(b) By causing a copy of the Meeting Notice to be delivered to a newspaper of general circulation in the geographic jurisdiction of the Issuer at least twenty-four (24) hours prior to the convening of the meeting.

(c) By causing a copy of the Meeting Notice to be posted on the Utah Public Notice Website at least 24 hours prior to convening the meeting.

(d) By causing a copy of the Meeting Notice to be delivered to each of the members of the governing body by electronic means.

In addition, the Notice of 2023 Annual Meeting Schedule for the Issuer, attached hereto as Schedule 2, specifying the date, time and place of the regular meetings of the governing body of the Issuer to be held during the calendar year 2023 was (1) posted on Feb 10, 2023, at the principal meeting place of the Issuer at 751 E. 100 N., Price, Utah and (2) provided to at least one newspaper of general circulation within the geographic jurisdiction of the Issuer on _____, 202___, and (3) posted on the Utah Public Notice Website on Feb 10, 2023.

IN WITNESS WHEREOF, I have hereunto subscribed my official signature this February 9, 2023.

Secretary

(SEAL)

SEVEN COUNTY INFRASTRUCTURE COALITION
SEAL
UTAH

[Attach Schedule 1, Meeting Notice]

[Attach Schedule 2, Annual Meeting Notice]

EXHIBIT "B"

MEMORANDUM OF INDUCEMENT AGREEMENT

[See Transcript Document No. ___]

EXHIBIT "C"

PROJECT DESCRIPTION

Finance, acquire, and construct rail surface transportation facility and related improvements of approximately 87 miles in length from the Kyune, Utah area near Soldier Summit in Utah County to the Uinta Basin, including freight transfer facilities and related improvements consistent with approval from the U.S. Surface Transportation Board dated December 15, 2021.

EXHIBIT "D"

FINAL BOND RESOLUTION

[See Transcript Document No. ___]

EXHIBIT 53

SEVEN COUNTY INFRASTRUCTURE COALITION

SEVEN COUNTY INFRASTRUCTURE COALITION
MEETING MINUTES
October 11, 2018 at 1:30 p.m.
152 E. 100 N., Vernal, UT 84078

Present: Jae Potter, Brad Horrocks, Lynn Sitterud & Greg Todd
Also in attendance - Mike McKee, Eric Johnson, Doug Rasmussen, Kristi Sharp, Brian Barton, Mike Hawley
Absent: Phil Lyman, Jack Lytle, Ken May
Attended telephonically: N/A

1. Welcome / Pledge of Allegiance (Jae Potter)

2. Meeting Minutes of September 14, 2018 meeting (Jae Potter)

   Motion to approve September 14, 2018 minutes by Commissioner Horrocks, seconded by Commissioner Todd. Unanimously approved 4-0-3 absent.

3. Public Comment (Jae Potter)

   No comments from public.

4. Finance Director Report and approval of Expenses (Smuin, Rich & Marsing)
   The following invoices were presented for approval.

Vendor	Invoice #	Amount	Description	Grant
CIVCO Engineering, Inc	2018409	40,186.66	I-70 Transportation Corridor - Engineering	Book Cliffs Transportation Corridor
ETJ Law	1395	2,447.42	Legal Services	General
ETJ Law	1397	1,435.00	Utilities - Legal Services	General
ETJ Law	1398	14,512.58	Uinta Rail Line - Legal Services	General
Smuin, Rich & Marsing	38424	1,950.00	Consulting Per Contract - Sept 2018	General
Mike McKee	Sep 6 - Oct 3, 2018	192.80	Director's Travel/Expenses	General
Jones & Demille	0118931	7,403.75	Engineering, Planning, Coordination	General
Jones & Demille	0118932	7,994.44	Leland Bench Utilities - Engineering	General
Jones & Demille	0118933	13,640.78	Uinta Rail Line - Engineering	General
Marc T. Eckels	SCIC 10-3-2018	3,675.00	Crude Oil Consultant	General
Total Payment Approval		**$ 93,438.43**		

Doug highlighted Kristi Sharp's diligent efforts with the CIB on reimbursements. Mike McKee offered his thanks for the Smuin Rich Marsing team efforts in obtaining timely reimbursements from the CIB. Mike McKee also asked to review the profit and loss summary prior to the monthly meetings with Doug. Brad Horrocks noted that Mike McKee is doing a great job with all the travel he does on so little expenses. Thanks!

Commissioner Horrocks confirmed the dollar amount of $93,438.43 and then made a Motion to approve, seconded by Commissioner Sitterud. Unanimously approved 4-0-3 absent.

Commissioner Horrocks exited the meeting at this point.

5. Executive Director Report (Mike McKee)

Rail Study Update:
The Coalition's Rail application will be heard in the CIB's November 8th meeting in Moab.

Leland Bench:
Discussions with Uintah Water Conservancy District and Ouray Park Improvement District on coordinating Green River water rights..

Thorium Energy Center of Excellence:
A meeting will be held next week at the Governor's office regarding getting this project in the legislative budget.

Eastern Connector Road:
Moving forward and legislative appropriation was received.

Western States Rural National Gas Initiative:
Bergen Eskildsen, of the Governor's Office of Energy Development, provided an update. He indicated that they are working on opening markets for local natural gas. Commissioner Potter asked if there is a timeframe. No known timeframe at this time. Both Duchesne and Uintah Counties also contributed.

6. Public Hearing on Rail CIB Application for $27,900,000 (Mike McKee)

Mike McKee provided background that the Coalition previously applied for $30,000,000 for Rail. This application revises the value to $27,900,000, to be utilized over a 2 year timeframe. The Coalition is on the CIB's agenda for the November 8th meeting regarding this application. Eric Johnson provided further background that several studies were done by HDR and R.L. Banks with routes to Colorado. Both studies indicated the Rail is viable, however, not at a rate of return that would entice private industry. Therefore, it would be appropriate for a public body to proceed with the Rail project for the public good. Eric Johnson indicated that a meeting was held with the Build America Bureau earlier this year. The Coalition will seek federal funding for the Rail project, which is estimated at $1.4B and the Coalition qualifies for an interest rate of approximately 1.7%, half of the current federal interest rate, which would be locked in at the start of construction of the project. The Build America Bureau that administers the federal funding also indicated that $35B in funding has been set aside for rail projects such as this.

Commissioner Horrocks re-joined the meeting at this point in time.

Motion to go into Public Hearing by Commissioner Todd, seconded by Commissioner Horrocks. Unanimously approved 4-0-3 absent.

Public comment:
Scott Hagman asked how Colorado feels about this project.

Mike McKee stated that meetings have been held with leaders and commissioners in Craig and Rifle Colorado, as well as a meeting with Kathleen Stacks of the Colorado Governor's Office of Energy. All of the Colorado participants seemed excited. Mr. McKee indicated that Ms. Stacks sent a letter to all government agencies in Colorado, to which no objections were received.

Brad Horrocks indicated overwhelming support from industry.

Motion to close Public Hearing by Commissioner Todd, seconded by Commissioner Horrocks. Unanimously approved 4-0-3 absent.

7. Resolution 2018-10A Approving Cody Deeter as Municipal Advisor for Utilities for Lube Oil Refinery (Mike McKee)

   Discussion of agenda item #6 was postponed until Commissioner Horrocks could re-join the meeting. The Coalition Board proceeded to introduce the background and purpose of agenda item #7, the Public Hearing (see more below).

   Mike McKee indicated his confidence in Cody Deeter as well-suited for this project. In order for the Board of Water Resources to fund the water utility for the Lube Oil Refinery, they require the entity to fund 15%. Mike McKee indicated the Coalition is in a position to meet the Board's requirements. Approving this resolution includes approving Mike Mckee to sign the agreement with Mr. Deeter.

   Motion to approve by Commissioner Horrocks, seconded by Commissioner Todd. Unanimously approved 4-0-3 absent.

8. Resolution 2018-10B Approving CIB Rail application (Mike McKee)

   Motion to approve by Commissioner Todd, seconded by Commissioner Horrocks. Unanimously approved 4-0-3 absent.

9. Finalizing Rail Planning Selection Committee (Mike McKee)

   Selection Committee will include: Executive Director, Engineer, Attorney, Uintah, Duchesne & Sevier county commissioners.

10. Monthly Infrastructure Report/Study Update (Jones and DeMille)

    Additional information on the utilities for Lube Oil Refinery.

11. Legal report on Rail (Eric Johnson)

    Prior practice of CIB and prior position of the Attorney General's office indicate that the

CIB can fund the rail project from general CIB funds and not draw on Throughput funds.

12. Closed (executive) Session for (**potential real estate acquisition**, trade secret related to procurement, **personnel competency**) pursuant to §52-4-205 (Eric Johnson)

    Motion to enter closed session at 2:52 p.m. by Commissioner Sitterud, seconded by Commissioner Todd. Unanimously approved 4-0-3 absent.

    Motion to re-enter open session by Commissioner Sitterud, seconded by Commissioner Horrocks. Roll call vote and unanimously approved 4-0-3 absent.

13. Motion to adjourn (Jae Potter)

    Motion to adjourn by Commissioner Horrocks, seconded by Commissioner Sitterud. Adjourned by acclimation.

Motion to approve meeting minutes by Commissioner Horrocks, seconded by Commissioner Burdick.

Missed last mtg

SEVEN COUNTY INFRASTRUCTURE COALITION VOTING:

Carbon	Board Member	Yea ___ No ___	abstained
Daggett	Board Member	Yea ___ No ___	abstained
Duchesne	Board Member	Yea ✓ No ___	
Emery	Board Member	Yea ✓ No ___	•
San Juan	Board Member	Yea ✓ No ___	
Sevier	Board Member	Yea ___ No ___	absent
Uintah	Board Member	Yea ✓ No ___	

Co-Chair Phil Lyman

Co-Chair Jae Potter

SEVEN COUNTY INFRASTRUCTURE COALITION SEAL UTAH

(COALITION SEAL)

ATTEST:

Eric Johnson

EXHIBIT 54

Texas rail company eyeing Colorado passenger service no longer involved with Utah oil trains

By David O. Williams
November 15, 2024, 12:45 pm



An oil train near the Grand Mesa in Colorado in 2023 (David O. Williams photo).

The Texas-based railroad company that holds a passenger-service lease with Union Pacific on the Tennessee Pass Line through Eagle County is no longer involved with the controversial Uinta Basin oil train proposal in Utah … and hasn't been since last year.

Despite still being listed as a partner on the Uinta Basin Railway website, Rio Grande Pacific Corporation (RGPC), out of Fort Worth, Texas, is no longer the railroad company of record for the proposed 88-mile Uinta Basin oil-train project, an RGPC spokesperson told RealVail.com via email on Tuesday.

"Rio Grande Pacific is no longer involved in the Uinta Basin project," an RGPC spokesperson confirmed. "This change occurred in 2023."

The Uinta Basin Railway project's approval by the U.S. Surface Transportation Board – the chief federal regulatory agency overseeing the nation's rail networks – was the target of an Eagle County lawsuit that will be heard by the U.S. Supreme Court on Dec. 10.

Eagle County and five conservation groups successfully opposed the surge in oil-train traffic along the Colorado Riverthat would result from connecting the Uinta Basin to the nation's main rail network, but the Seven County Infrastructure Coalition in Utah petitioned the Supreme Court to hear the case, relying on a narrow interpretation of the National Environmental Policy Act.

RGPC's withdrawal from the oil-train project is noteworthy because the Texas company, which remains interested in providing passenger service on the line between Gypsum and the Royal Gorge – running along the Eagle and Arkansas rivers – has long sought to distance itself from the return of hazardous freight on the UP-owned line, which has been out of service since 1997.

RGPC still holds a lease deal it inked with Union Pacific in 2021, although the STB rejected a request for expedited approval of the lease because of potential opposition along the line and the need for more scrutiny. Before that happened in 2021, RGPC had sought to amend the lease to "restrict … the transportation of crude oil, coal and hazardous commodities" on the line.

Last month, with the formation of the Western Rail Coalition (WRC) that RGPC is not a part of, an RGPC spokesperson confirmed its interest in reviving the original passenger-rail lease if there's enough local support:

"Rio Grande Pacific remains interested in coordinating with communities along the Tennessee Pass rail line to determine whether there is interest in developing commuter/passenger rail. Additionally, RGPC is open to the potential of other local, non-hazmat freight that originates or terminates within the corridor between Eagle County Airport and Parkdale in Fremont County. We believe the existing rail line could play a role in state and local passenger rail goals, as well as broader community and economic development plans, workforce housing access and commuter needs, climate action goals, and more within this transportation corridor that links world class recreation and resorts, higher education institutions, airports and communities."

The Western Rail Coalition, a group of passenger rail advocates with six local backers in Eagle and Garfield counties, sent a letter to the administration of Colorado Gov. Jared Polis and the head of the Colorado Department of Transportation (CDOT) seeking the study of a potential passenger line from Glenwood Springs to Leadville using diesel multiple unit (DMU) trains that are 75% quieter and less polluting than traditional diesel locomotives.

According to the Rio Grande Pacific Corporation (RGPC) website, the company "is a privately held, Fort Worth, Texas-based holding company for regional freight railroads. Through various subsidiaries, RGPC provides complementary services, including signal construction and design, passenger operations,

equipment remanufacturing and dispatching services, to short line railroads and transit agencies across the United States."

RGPC formed a company called Colorado Midland Pacific to pursue the Tennessee Pass Line lease deal with UP, which has a long history with RGPC. Its first short line railroad was acquired from UP in 1990.

The Tennessee Pass Line (TPL) will require extensive refurbishing if it is to be revived. It has been dormant, or out of service and never officially abandoned, since the merger of UP and former TPL-owner Southern Pacific in 1996. If UP was to file to abandon the line now, it would be opening itself up to an Offer of Financial Assistance (OFA) from a competing railroad company that could result in UP losing the line.

Rail experts say the 3% grade on the western side of Tennessee Pass down into Minturn makes it highly unlikely any railroad company would want to try to transport oil or other hazardous materials over the line these days given that capacity is available on the active Moffat Subdivision that already carries oil trains from Utah along the Colorado River through Grand Junction, Dotsero and Bond in Eagle County, then through the Moffat Tunnel at Winter Park and down into Denver. Trains from there can then travel south toward Gulf Coast refineries.

Peter Rickershauser is a retired rail executive in Denver who worked for Southern Pacific and briefly for Union Pacific before being recruited away to competing Class 1 freight carrier Burlington Northern Santa Fe to head up network development. His first job at BNSF, which he continued until leaving the company in 2010, was implementation of the UP/SP merger settlement agreements. BNSF was brought in by the STB as the competition in the UP/SP merger.

"Let's talk about the physical characteristics of Tennessee Pass Line because this is something that makes me laugh when I hear people being concerned about oil trains," Rickershauser said in a recent phone interview, explaining the active Moffat Subdivision has an average 2% grade on both sides of the tunnel, while the TPL up to the pass at Ski Cooper averages 3%.

"Railroading, I like to say, is a game of physics. The shortest, straightest, flattest route wins," Rickershauser said. "So given their druthers, as long as there's capacity through the Moffat, they're going to go that way. The last thing you would want to drag up Tennessee Pass is an oil train, or a coal train, because of the grade."

Two-mile-long oil trains, with heated tanker cars to accommodate Uinta Basin's waxy crude that can't travel through pipelines, would require numerous locomotives burning a lot of fuel on the TPL – plus there's added safety factor that makes the route prohibitive, Rickershauser said.

Lastly, as a Colorado resident, he thinks the state needs to keep its transit options open, especially with an existing rail line that could connect to the Eagle County Regional Airport.

"Everybody needs to think long-term and everybody needs to think about preserving and enhancing mobility," Rickershauser said. "And before somebody yanks up one of these rail lines, they need to make sure that they will never regret having done that. Whether the technology exists right now or not, these corridors, once they're gone, are irreplaceable."

Rickershauser points to Aspen as a case study for what happens when a rail line is converted to a recreational trail and now transportation officials and local residents are struggling to deal with increasing car and truck traffic on U.S. Highway 82. In the 1990s there was a rails to trails plan drawn up for the TPL that never came to fruition.

Related Posts:

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- Federal agencies that approved project oppose… Oil tanker rail cars rolling along the Colorado River in…
- U.S. Forest Service pulls plug on approval for Uinta… A United States Forest Service map shows the route, in…
- Western Rail Coalition looks to revive passenger… A Stadler DMU train is about 75% quieter and cleaner…

Bio | Latest Posts



David O. Williams

David O. Williams is an award-winning freelance reporter based in the Vail Valley of Colorado, writing on health care, immigration, politics, the environment, energy, public lands, outdoor recreation and sports. His work has appeared in 5280 Magazine, American Way Magazine (American Airlines), the Anchorage Daily News (Alaska), Aspen Daily News, the Aspen Times, Beaver Creek Magazine, the Chicago Tribune, the Colorado Independent, Colorado Politics formerly the Colorado Statesman), Colorado Public News, the Colorado Springs Gazette, the Colorado Independent (formerly Colorado Confidential), the Colorado Springs Independent, the Colorado Statesman (now Colorado Politics), the Daily Trail (Vail), the Denver Daily News, the Denver Post, the Durango Herald, the Eagle Valley Enterprise, the Eastside Journal (Bellevue, Washington), ESPN.com, the Glenwood Springs Post-Independent, the Greeley Tribune, the Huffington Post, the King County Journal (Seattle, Washington), KUNC.org (northern Colorado), LA Weekly, the London Daily Mirror, the Montgomery Journal (Maryland), The New York Times, the Parent's Handbook, Peaks Magazine (now Epic Life), People Magazine, Powder Magazine, the Pueblo Chieftain, PT Magazine, Rocky Mountain Golf Magazine, the Rocky Mountain News, Atlantic Media's RouteFifty.com (formerly Government Executive State and Local), SKI Magazine, Ski Area Management, SKIING Magazine, the Summit Daily News, United Hemispheres (United Airlines), Vail/Beaver Creek Magazine, Vail en Español, Vail Valley Magazine, the Vail Daily, the Vail Trail and Westword (Denver). Williams is also the founder, publisher and editor of RealVail.com and RockyMountainPost.com.

EXHIBIT 55

Savannah Industrial Logistics, LLC and Savannah Industrial Transportation, LLC After-the-Fact Construction and Operation of Rail Line

Effingham County, Georgia

Docket Nos. FD 36723 and FD 36723 (Sub-No. 1)

DRAFT ENVIRONMENTAL ASSESSMENT



Information Contact:

Karen Stevens, Environmental Protection Specialist

Surface Transportation Board
Office of Environmental Analysis
395 E. Street, SW
Washington, DC 20423

202.245.0304

Summary

S.1 Introduction

On September 28, 2023, Savannah Industrial Logistics, LLC (SIL) filed a petition in Docket No. FD 36723, seeking authorization from the Surface Transportation Board (the Board) for after-the-fact authority to construct an 11,404 foot rail line in Effingham County, Georgia (the Line), and Savannah Industrial Transportation, LLC (SIT), an affiliate of SIL, filed for after-the-fact authority to lease and operate the same Line in Docket No. 36723 (Sub-No. 1). SIL and SIT are both holdings of OmniTRAX Holding Combined, Inc. (OmniTRAX). The Line is located in an industrial park, the Savannah Gateway Industrial Hub (SGIH), near the City of Rincon. The Line provides SGIH with dual access to two large Class I railroads: Norfolk Southern Railway (NSR) and CSX Transportation, Inc. (CSXT). The Line has no mileposts and extends from a connection with NSR to the west, near NSR milepost 16.6, to a connection with CSXT to the east, near CSXT milepost S484.0. SGIH is located 12 miles from the Port of Savannah, Georgia, and five miles northwest of Interstate 95 (I-95), the main north-south interstate on the East Coast.

Construction and operation of new common carrier rail lines require prior authorization by the Board, either through an application under 49 U.S.C. § 10901 or an exemption from the formal application requirements of § 10901 under § 10502. However, the Line already exists because it was constructed and leased without the requisite Board authority. OmniTRAX and SIL had previously constructed the Line as a part of a larger project to construct the SGIH, without seeking Board authorization or undergoing environmental review under the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370m-11, and historic review under Section 106 of the National Historic Preservation Act (NHPA), 54 U.S.C. § 306108, by the Board.

Before deciding whether to authorize the after-the-fact construction and lease and operation of the Line, the Board must consider the impacts of that decision on the environment. The after-the-fact environmental and historic review of the construction and operation of the Line is provided in this Draft Environmental Assessment (Draft EA).

S.2 Purpose and Need

The after-the-fact construction, lease, and operation of the Line has not been proposed or sponsored by the federal government. Notably, the Line was constructed and leased without the required Board authority.[1] Here, the proposed federal action is the Board's decision to approve with appropriate conditions, or deny, SIL's request for after-the fact authority to construct approximately 11,404 feet of rail line, and SIT's request for after-the-fact authority to lease and operate the same line. If the Board grants SIL and SIT's petitions, SIT would be able to operate the approximately 11,404 feet of previously constructed rail line as a common carrier. As a

[1] See Savannah Industrial Transportation, LLC – Operation Exemption – In Effingham County, Ga., FD 36489 (STB served August 1, 2023).

common carrier, SIT would be required to provide rail service to any shipper upon reasonable request. 49 U.S.C. § 11101(a).

The purpose and need for the Line is informed by the goals of SIL and SIT in conjunction with the Board's enabling statute—sections 10502 and 10901 of the Interstate Commerce Act, as amended by the ICC Termination Act, Pub. L. No. 104-188, 109 State. 803 (1996). According to SIL and SIT, the purpose of the Proposed Action is to ensure the development and continuation of a sound rail transportation system and to provide alternative transportation options for all current and future tenants at the SGIH, which would benefit from nearby connections to two large Class I rail carriers (NSR and CSXT) as well as I-95 and the nearby Port of Savannah. SIL and SIT state that the Proposed Action would maintain and enhance competition among rail carriers and with other transportation modes.

S.3 Draft EA and Final EA Process

The Board's Office of Environmental Analysis (OEA) is responsible for conducting the environmental and historic review process, independently analyzing environmental data, and making environmental recommendations to the Board. OEA is issuing this Draft EA for public review and comment for 30 days. Comments are due by **May 12, 2025**. OEA will consider all timely comments received on this Draft EA and, in the Final EA, will respond to substantive comments and provide OEA's final recommended environmental mitigation. In making its final decision on whether to authorize the Line, the Board will consider the entire record, including the Draft EA and Final EA, all comments received, OEA's recommendations, and the transportation merits of the proposal.

S.4 Alternatives

NEPA directs federal agencies to consider "a reasonable range of alternatives to the proposed agency action, including an analysis of any negative environmental impacts of not implementing the proposed agency action in case of a no action alternative, that are technically and economically feasible, and meet the purpose and need of the proposal." 42 U.S.C.§ 4332(C)(iii)

OEA has carried forward the Proposed Action and the No-Action Alternative for detailed analysis. Because the Line had already been constructed, OEA concluded that there are no other technically and economically feasible alternatives to analyze in this Draft EA.

S.5 Summary of Impacts

S.5.1 No-Action Alternative

Under the No-Action alternative, the Board would not authorize the after-the-fact rail construction, nor would the Board authorize SIT to lease and operate as a common carrier on the same track. Without the requisite Board authority, rail service on the Line would cease, and no trains would operate on the Line. Therefore, potential environmental impacts associated with operation of the Line would not occur. Furthermore, the current shipper served by SIT would

lose access to rail service. Since the Line has already been constructed, the track would remain in place.

S.5.2 Proposed Action

Under the Proposed Action, the Board would authorize SIL's "after-the-fact" construction of the 11,404-foot rail line, as well as SIT's "after-the-fact" lease and operation of the same rail line as a common carrier. If the Board authorizes both actions, SIT would be able to operate the previously constructed rail line as a common carrier rail line and would be required to provide rail service to any shipper within the SGIH upon reasonable request.

As explained in this Draft EA, the Proposed Action would not involve any new rail construction, as the Line was constructed in 2020 (see **Section 2.2.1**). However, OEA analyzed both the potential impacts that could have resulted from construction of the Line, where possible, and the potential impacts that could result from the continued operation of the Line (see **Chapter 3**).

The impacts of the Proposed Action range from no impacts or *de minimis* to minimal impacts. The resources for which the Proposed Action would have no or *de minimis* impacts are:

- Air quality
- Energy
- Cultural resources
- Hazardous materials
- Transportation
- Land use
- Noise

The resources for which the Proposed Action would have minimal impacts are:

- Biological resources
- Water resources

S.5.3 Mitigation

OEA is preliminarily recommending one mitigation measure (**WAT-MM-1**) to minimize impacts from continued rail operations. To ensure all project-related culverts are clear of debris to avoid flow blockages, flow alteration, and increased flooding, OEA is recommending that the Board require SIT to inspect all project-related culverts semi-annually (or more frequently, as seasonal flows dictate) for debris accumulation and remove and properly dispose of debris promptly. OEA will make its final recommendations on mitigation to the Board in the Final EA after considering all public comments on this Draft EA.

S.6 Conclusion

OEA concludes that the Proposed Action would have negligible impacts on all environmental resource areas, except for biological resources and water resources. Due to the removal of forested habitat during construction of the Line, OEA concludes that the Proposed Action could

have had minor impacts on biological resources from construction of the Line and *de minimis* impacts from continued rail operations. Construction of the Line resulted in impacts to water resources that were previously mitigated with the purchase of compensatory mitigation credits from an approved mitigation bank and the use of appropriate Best Management Practices. If OEA's recommended mitigation measure (**WAT-MM-1**) is imposed, OEA also concludes that the Proposed Action would have negligible impacts on water resources from continued rail operations.

S.7 Draft EA Public Comment Period

This Draft EA is available for viewing and downloading on the Board's website (www.stb.gov). It can be accessed by clicking "Search STB Records" near the top of the home page and then searching for "Decisions" using Docket Numbers FD 36723 and FD 36723 (Sub-No. 1). In addition, a hard copy of the Draft EA is available at the local libraries identified in **Table 1-1** of the Draft EA. **Table 1-1** also includes the address, telephone, website, and operating hours for each location.

OEA invites comments on all aspects of this Draft EA and will consider all timely comments received. All comments on this Draft EA must be submitted by the comment due date, within the comment period, which will close in 30 days on **May 12, 2025**. When submitting comments on this Draft EA, OEA encourages commenters to be as specific as possible and to substantiate concerns and recommendations. Comments on this Draft EA may be submitted electronically through the Board's website at www.stb.gov by clicking on the "E-Filing" link on the left side of the home page and then selecting "Environmental Comments." Brief comments may be typed within the comment field provided, or longer comments may be attached as a separate file. Alternatively, comments on this Draft EA can be mailed to:

Karen Stevens
Surface Transportation Board
Environmental Filing, Docket Nos. FD 36723 and FD 36723 (Sub-No. 1)
395 E. Street SW
Washington, DC 20423

It is not necessary to mail written comments that have been filed electronically. Please refer to Docket No. FD 36723 or FD 36723 (Sub-No. 1) in all correspondence addressed to the Board, including all comments submitted on the Draft EA.

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Acronyms

AADT	Average Annual Dailly Traffic
APE	Area Of Potential Effects
AR-1	Agricultural Residential
B-2	General Commercial
ASTM	American Society for Testing and Materials
BGEPA	Bald And Golden Eagle Protection Act
BMPs	Best Management Practices
Board	Surface Transportation Board
CadnaA	Computer Aided Noise Abatement
C.F.R.	Code Of Federal Regulations
CLOMR	Conditional Letter Of Map Revision
CWA	Clean Water Act
CO	Carbon Monoxide
CRC	Coastal Regional Commission
CSS	Coastal Stormwater Supplement
CSXT	CSX Transportation, Inc.
CZMA	Coastal Zone Management Act
dBA	A-Weighted Decibels
DNL	Day-Night Average Noise Level
DNR	Georgia Department of Natural Resources
EA	Environmental Assessment
EDGES	Effects Determination Guidance for Endangered & Threatened Species
EDR	Environmental Data Resource
EPD	Environmental Protection Division
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FLCP	Florida Central & Peninsular Railroad
FR	Federal Register

FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GCMP	Georgia Coastal Management Program
GDOT	Georgia Department of Transportation
GNAHRGIS	Georgia's Natural, Archaeological, And Historic Resources Geographic Information System
GRAD	Georgia Ready for Accelerated Development
I-1	Light Industrial
IPaC	Information For Planning and Consultation
LDM	Local Design Manual
Ldn	Day-Night Average Noise Level
LOS	Level Of Service
MBTA	Migratory Bird Treaty Act
MJ	Million Joules
MPC	Metropolitan Planning Commission
MPH	Miles Per Hour
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFA	No Further Action
NHPA	National Historic Preservation Act
NOx	Oxides of Nitrogen
NRHP	National Register Of Historic Places
NSR	Norfolk Southern Railway
NWI	National Wetlands Inventory
NWP	Nationwide Permit
O_3	Ozone
OEA	Office Of Environmental Analysis
OmniTRAX	OmniTRAX Holding Combined, Inc.
OSHA	Occupational Safety and Health Administration
PD	Planned Development
PD-R	Residential Mixed Use
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with a Particle Diameter Less Than or Equal to 2.5 Microns

PM_{10}	Particulate Matter with A Particle Diameter Less Than or Equal to 10 Microns
RIBITS	Regulatory In-Lieu Fee and Bank Information Tracking System
SGIH	Savannah Gateway Industrial Hub
SHPO	State Historic Preservation Office
SPCC	Spill Prevention, Control, And Countermeasure
SIL	Savannah Industrial Logistics, LLC
SIT	Savannah Industrial Transportation, LLC
SO_2	Sulfur Dioxide
STB	Surface Transportation Board
SVAT	Savannah & Atlanta Railroad
THPO	Tribal Historic Preservation Officer
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VdB	Vibration Decibels
VOCs	Volatile Organic Compounds
WOTUS	Waters Of the United States
WSE	Water Surface Elevation

Chapter 1
Purpose and Need

1.1 Introduction

On September 28, 2023, Savannah Industrial Logistics, LLC (SIL) filed a petition in Docket No. FD 36723 seeking authorization from the Surface Transportation Board (the Board) for after-the-fact authority to construct an 11,404 foot rail line in Effingham County, Georgia (the Line); and Savannah Industrial Transportation, LLC (SIT), an affiliate of SIL, filed for after-the-fact authority to lease and operate the same Line in Docket No. 36723 (Sub-No. 1). SIL and SIT are both holdings of OmniTRAX Holding Combined, Inc. (OmniTRAX). The Line, which is located in the Savannah Gateway Industrial Hub (SGIH), an industrial park, near the City of Rincon, provides dual access to two large Class I railroads, Norfolk Southern Railway (NSR) and CSX Transportation, Inc. (CSXT). The Line has no mileposts and extends from a connection with NSR to the west, near NSR milepost 16.6, to a connection with CSXT to the east, near CSXT milepost S484.0 (see **Figure 1-1**). The SGIH is located 12 miles from the Port of Savannah, Georgia and five miles northwest of Interstate 95 (I-95), the main north-south interstate on the East Coast.

1.1.1 Background

Construction and operation of new common carrier rail lines require prior authorization by the Board, either through an application under 49 U.S.C. § 10901 or an exemption from the formal application requirements of § 10901 under § 10502. However, the Line already exists because it was constructed and leased without the requisite Board authority.

These proceedings began on May 12, 2021, when SIT filed a petition for an exemption in Docket No. 36489 to operate as a common carrier over track leased from SIL. OmniTRAX and SIL had previously constructed the Line as a part of a larger project to construct the SGIH, without seeking Board authorization or undergoing environmental review under the National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321-4370m-11, and historic review under Section 106 of the National Historic Preservation Act (NHPA), 54 U.S.C. § 306108, by the Board. On August 1, 2023, the Board served a decision finding that SIT and its parent company, OmniTRAX, intended to operate and were operating the Line as a common carrier rail line for which Board authority should have been obtained under 49 U.S.C. § 10901 or § 10502 before construction and operation commenced.[2] The Board therefore held SIT's petition in abeyance, ordered SIL to file for after-the-fact construction authority, and ordered SIT to file for after-the-fact acquisition authority. The Board also granted SIT a limited exemption to continue providing service to any shippers located on the track as of August 1, 2023, during the pendency of the construction and acquisition proceedings.[3] As noted above, on September 28, 2023, SIL

[2] Savannah Indus. Transp., LLC—Operation Exemption—in Effingham Cnty., Ga. (August 2023 Decision), FD 36489, slip op. at 4, 6 (STB served Aug. 1, 2023).

[3] On August 30, 2023, SIT informed the Board that as of that date it was providing rail service to only one shipper on the Line, Quantix SCS, Inc. f/k/a A&R Logistics, Inc (Quantix). (SIT Suppl. 1, Aug. 30, 2023, FD 36489.)

petitioned the Board for a construction exemption in Docket No. FD 36723, and SIT petitioned the Board for a lease and operation exemption in Docket No. FD 36723 (Sub-No. 1).[4] On February 9, 2024, SIL and SIT filed a petition for clarification or other relief seeking Board authority to serve additional shippers during the pending construction and lease and operation proceedings, which the Board denied.[5]

Before deciding whether to authorize the after-the-fact construction and lease and operation of the Line, the Board must consider the impacts of that decision on the environment. The after-the-fact environmental and historic review of the construction and operation of the Line is provided in this Draft Environmental Assessment (Draft EA).

1.2 Purpose and Need

The after-the-fact construction, lease, and operation of the Line has not been proposed or sponsored by the federal government. Notably, the Line was constructed and leased without the required Board authority. Here, the proposed federal action is the Board's decision to approve with appropriate conditions, or deny, SIL's request for after-the fact authority to construct approximately 11,404 feet of rail line, and SIT's request for after-the-fact authority to lease and operate the same line. If the Board grants SIL and SIT's petitions, SIT would be able to operate the approximately 11,404 feet of previously constructed rail line as a common carrier. As a common carrier, SIT would be required to provide rail service to any shipper upon reasonable request. 49 U.S.C. § 11101(a)

The purpose and need for the Line is informed by the goals of SIL and SIT in conjunction with the Board's enabling statute—sections 10502 and 10901 of the Interstate Commerce Act, as amended by the ICC Termination Act, Pub. L. No. 104-188, 109 State. 803 (1996). According to SIL and SIT, the purpose of the Proposed Action is to ensure the development and continuation of a sound rail transportation system and to provide alternative transportation options for all current and future tenants at the SGIH, which would benefit from nearby connections to two large Class I rail carriers (NSR and CSXT) as well as I-95 and the nearby Port of Savannah. SIL and SIT state that the Proposed Action would maintain and enhance competition among rail carriers and with other transportation modes.

1.3 Role of the Board

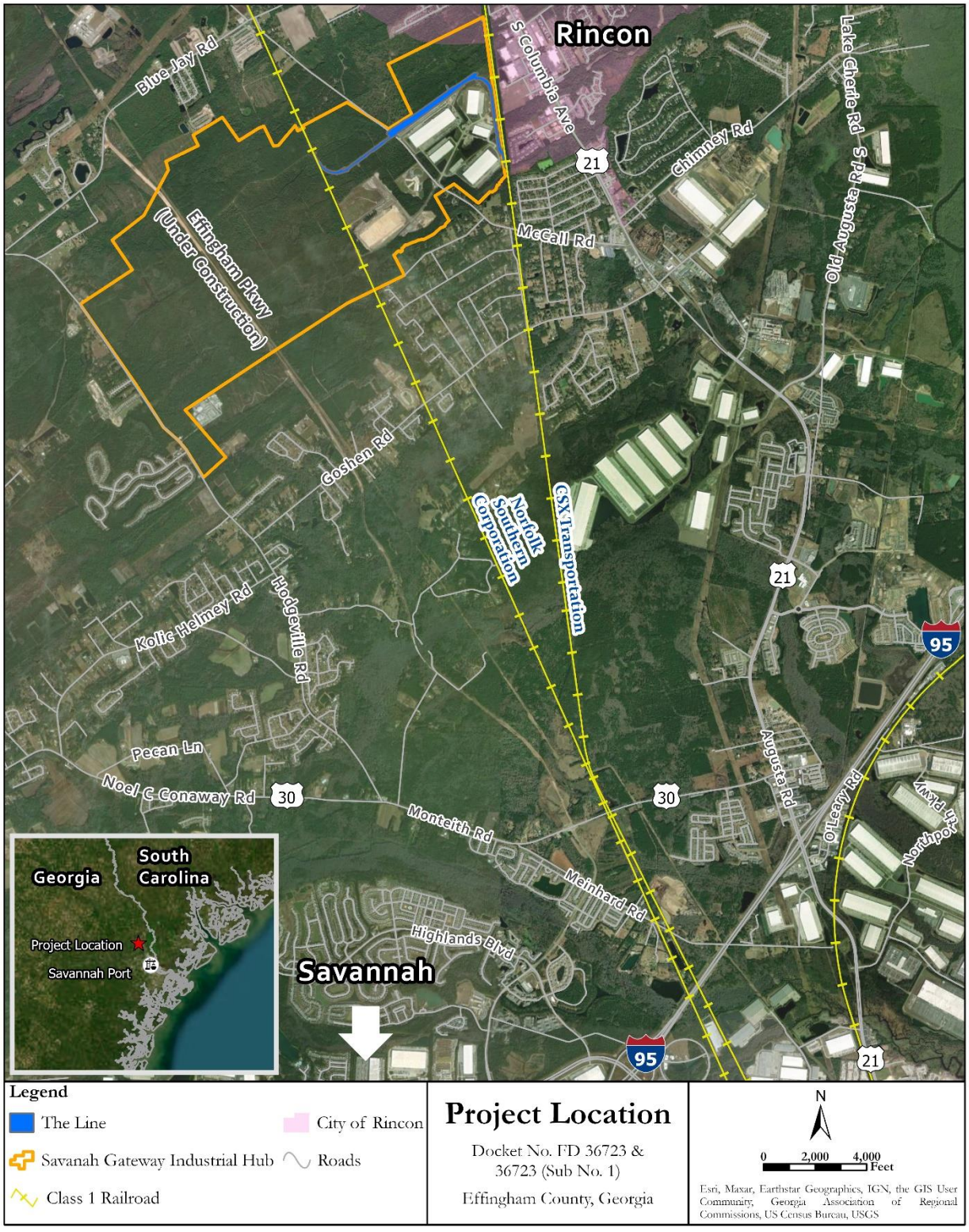
The Board is a nonpartisan, federal regulatory agency, composed of five presidentially appointed Members confirmed by the Senate.[6] The Board has jurisdiction over certain rail transportation

[4] Additional background information can be found in the Board's decisions in Docket Nos. FD 36489, FD 36723, and FD 36723 (Sub-No. 1). These decisions and related filings can be found on the Board's website at www.stb.gov.

[5] Savannah Industrial Transp., LLC—Operation Exemption—In Effingham Co., Ga., FD 36489, slip op. at 3 (STB served May 28, 2024). There, the Board reiterated that its August 2023 decision "clearly prohibits SIT from providing rail transportation on the Line to anyone other than Quantix, the single shipper that was already located on the Line and receiving rail service from SIT as of August 1, 2023" until SIT obtains the needed Board authority.

[6] The Board is currently composed of four Members with one vacancy.

Figure 1-1 Project Location Map



matters, including the construction and operation of new rail lines. The Board licenses railroads as common carriers, requiring them to accept goods and materials for transport from all customers upon reasonable request (49 U.S.C. § 11101(a)).

1.4 NEPA and NHPA Process

The Board is required to examine the potential environmental and historic impacts of actions subject to its licensing authority under NEPA, NHPA, and related environmental laws. The environmental and historic review process is intended to assist the Board and the public in identifying and assessing the potential environmental and historic consequences of a Proposed Action. The Board's Office of Environmental Analysis (OEA) is the office within the Board responsible for ensuring the agency's compliance with NEPA, NHPA, and related environmental laws and regulations.

As part of the environmental review process, OEA makes recommendations to the Board regarding measures for mitigating potential adverse environmental impacts that could occur as a result of a Board decision. Environmental mitigation measures may include voluntary measures developed by railroad applicants and additional measures recommended by OEA. When making its final decision in this case, the Board will consider OEA's conclusions regarding environmental impacts and OEA's final recommendations for mitigation.

1.4.1 Determination to Prepare an Environmental Assessment

Based on information provided by SIL and SIT,[7] as well as comments received during consultation with federal, state, and local agencies and Tribes conducted in May and June of 2024, OEA determined that the preparation of an Environmental Assessment (EA), instead of an Environmental Impact Statement (EIS), is appropriate in this case under 49 C.F.R. §1105.6(d).[8] OEA granted SIL and SIT's request for a waiver of the preparation of an EIS on August 7, 2024, for the following reasons:

- OEA conducted preliminary agency and Tribal consultation and requested formal comments by June 5, 2024. Minimal concerns regarding the project were raised.
- OEA visited the project area on June 25, 2024, to better understand existing conditions. OEA found that the project area is currently disturbed; development of the SGIH has been proceeding independently of rail line access; and the Line, as noted above, has

[7] Surface Transportation Board, (Aug. 29, 2024) (Environmental Comment EI-33619), FD-36723 and FD-36723 (Sub-No. 1). Accessed: https://www.stb.gov/proceedings-actions/dockets and-service-lists/

[8] While the Board's regulations under 49 C.F.R. §1105.6(a) state that EISs will normally be prepared for rail construction projects, under 49 C.F.R. §1105.6(d), the Board may reclassify or modify these requirements for individual proceedings. In practice, OEA prepares EAs for construction projects where it does not expect impacts to be significant.

already been constructed.[9] Moreover, some environmental review for the Line was completed prior to construction.[10]

- OEA understands that approximately one train is currently moving on the Line, and that the projected number of trains was expected to remain the same.[11] Due to the small volume of expected rail traffic, the potential for impacts related to air quality, safety, and noise during rail operations are expected to be low.

1.5 Agency and Tribal Consultation

On May 6, 2024, OEA consulted with relevant federal, state, and local agencies, and Tribes. OEA sent letters to 45 agency and Tribal contacts providing background information on the Proposed Action. The consultation letter, along with a list of agencies and Tribes consulted, is provided in **Appendix A**. OEA gave the agencies and Tribes a 30-day timeframe to provide comments to assist OEA in identifying potential impacts and any additional concerns associated with the Proposed Action.

OEA received nine comments from agencies, including comments from Effingham County Schools, Savannah Chatham County Metropolitan Planning Commission (MPC), and the Georgia Department of Transportation (GDOT) (see **Appendix A**). This Draft EA contains an appropriate analysis of resource areas raised in the comments, including safety of the at-grade crossing and noise into the environmental and historic analysis, in **Chapter 3**.

Section 106 Consultation

OEA has assessed the potential effects of the Proposed Action on historic properties that are listed in or are eligible for listing in the National Register of Historic Places (NRHP), as required by Section 106 of the NHPA. As a part of agency coordination efforts, OEA initiated consultation with the Georgia State Historic Preservation Office (SHPO), Tribal Historic Preservation Officers (THPOs), and Tribal governments with a possible interest in the Proposed

[9] As shown in **Figure 2-1**, five sites have been fully developed east of McCall Road. Land has been cleared west of McCall Road and Blanford Elementary school for additional sites. According to the SGIH website (https://savannahgatewayindustrialhub.com/), rail and non-rail sites are available with the ability to develop over 18 million square feet of logistics facilities.

[10] Prior environmental review included a Development Plan Application, a Wetland Survey, a Habitat Assessment for Threatened and Endangered Species, a Cultural Resources Survey, a Traffic Impact Study, a Sewer and Reuse Water Master Plan, a Drainage Report, and an Environmental Site Assessment. More information on the environmental reviews completed prior to construction is discussed in **Chapter 3** *Affected Environment and Environmental Impacts*.

[11] After the determination was made to prepare an EA, SIL and SIT updated current and projected operation information in response to an information request. The revised information provided the following: SIT operates one round trip (one train, two train movements) five days per week to interchange with NSR and one round trip (one train, two train movements) five days per week to interchange with CSXT for a total of two trains per day. By 2029, SIL and SIT projects SIT would operate four trains per day. OEA reviewed the updated information and found 1) the projected train traffic would remain low, and 2) the potential for impacts related to air quality, safety, and noise during operations were still expected to be low. Therefore, OEA determined preparation of an EA was still adequate.

Action. OEA consulted and coordinated with the Alabama-Quassarte Tribal Town, Catawba Indian Tribe of South Carolina, Coushatta Tribe of Louisiana, Muscogee (Creek) Nation, and Seminole Tribe of Florida. No responses were received from the Tribes. In a letter dated June 4, 2024, OEA received a response from the Georgia SHPO concluding that the Proposed Action would have No Adverse Effect to historic properties located within the Area of Potential Effect for the Proposed Action, as defined in 36 C.F.R. Part 800.5(d)(1), due to the scope and location of the work, existing modern intrusions, and previous ground disturbance. (See **Appendix A**).

Section 7 Consultation

U.S. Fish and Wildlife Service (USFWS) is the federal agency with primary expertise in fish, wildlife, and natural resource issues. USFWS is responsible for implementing the Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544), and it is also responsible for implementing the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712) and the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. §§ 668-668d). Under Section 7 of the ESA, OEA initiated consultation with USFWS regarding the potential effects of the Proposed Action on ESA-listed species that may occur in the project area. OEA received a response from USFWS, dated May 9, 2024, stating that the project is not expected to impact ESA listed species. See **Section 3.6** for more information. See **Appendix A** for the species list, consistency letter, and USFWS response.

1.6 Requests for Comments and Next Steps

This Draft EA examines existing environmental conditions and potential environmental and historic impacts associated with the Proposed Action and the No-Action Alternative, consistent with NEPA, and other relevant environmental laws. This Draft EA will be available to the public for a 30-day comment period that ends on **May 12, 2025**. Interested agencies, Tribes, individuals, and other stakeholders are encouraged to submit detailed and substantive comments on this Draft EA during the 30-day comment period. A physical copy of the Draft EA is available for review at the local library and town hall identified in **Table 1-1**.

Table 1-1 Draft EA Hard Copy Locations

Rincon Library 105 W 17th St, Rincon, GA 31326 Phone: 912-826-222 https://www.liveoakpl.org/home Hours: Tuesday through Friday 10:00 a.m. to 6:00 pm; Monday 10:00 a.m. to 7:00 p.m.; Saturday 10:00 a.m. to 2:00 p.m.
City of Rincon Municipal Building 302 S Columbia Ave, Rincon, GA 31326 Phone: 912-826-5745 https://www.cityofrincon.com/ Hours: Monday through Friday 8:00 a.m. to 5:00 p.m.

Interested parties are encouraged to file their written comments electronically through the Board's website, www.stb.gov, by clicking on the "File an Environmental Comment" link. Please refer to Docket Numbers FD 36723 and FD 36723 (Sub-No.1) in all correspondence, including e-filings, addressed to the Board. Comments also may be submitted by mail, addressed to:

Karen Stevens
Surface Transportation Board
Environmental Filing, Docket Nos. FD 36723 and FD 36723 (Sub-No. 1)
395 E. Street SW
Washington, DC 20423

It is not necessary to mail written comments that have been filed electronically. Please refer to Docket Nos. FD 36723 and FD 36723 (Sub-No. 1) in all correspondence, including all comments submitted to OEA on the Draft EA.

Comments on this Draft EA must be received or postmarked within the published comment period, which will close in 30 days on **May 12, 2025**. All comments received—mailed or e-filed—will carry equal weight in helping to complete the EA process and guide the Board in making a decision in these proceedings. If you require an accommodation under the Americans with Disabilities Act, please call (202) 245-0245.

Following the close of the comment period on the Draft EA, OEA will issue a Final EA that will consider and respond to all comments received on the Draft EA and make any modifications necessary to the existing environmental analysis. The Final EA will set forth OEA's final recommended environmental mitigation measures to the Board. The Board will then consider the entire record, including the record on the transportation merits, the Draft EA, the Final EA, all public comments received, and OEA's final recommended environmental mitigation measures in making its final decision in these proceedings. The Board's final decision will determine whether to authorize the after-the-fact construction and operation of the Line, and if so, what, if any, environmental mitigation conditions to impose.

Chapter 2
Proposed Action and Alternatives

Based on the Board's August 1, 2023 decision, the purpose and need for the Proposed Action, information provided by OmniTRAX, comments received to date, and OEA's independent analysis, OEA has carried forward the Proposed Action and the No-Action Alternative for detailed analysis in this Draft EA. Because the Line has already been constructed, OEA concluded that there are no additional alternatives to analyze in this Draft EA.

2.1 Overview of Existing Rail Operations

Currently, SIT provides rail service to one customer within the SGIH.[12] CSXT and NSR deliver and pick up rail cars (i.e., interchange) with SIT. SIT operates approximately one round trip (one train, two train movements) five days per week to interchange with NSR and one round trip (one train, two train movements) five days per week to interchange with CSXT for a total of two trains per day. Loaded trains move from the interchange with NSR or CSXT towards the SIT yard, and empty trains move from the SIT yard to NSR or CSXT. SIT currently operates Monday through Friday from 5:00 AM until 2:00 PM. NSR interchange occurs before noon and CSXT interchange occurs after noon. SIT switches customer rail cars and builds trains to interchange beginning at approximately 5:30 AM until complete. During morning peak traffic, SIT does not block the only at-grade crossing located on the Line at McCall Road.

SIT trains typically consist of approximately 10 railcars, spanning 720 feet. Average train speeds reach a maximum of approximately 10 miles per hour (mph) at the McCall Road crossing. Current annual gross inbound tonnage consists of approximately 715,000 tons, while annual gross outbound tonnage consists of approximately 176,000 tons. According to SIT, when the locomotives are not in use, they are shut down; thus, there are no idling locomotives.

2.2 Proposed Action

This Draft EA analyzes two proposed federal actions—whether to authorize "after-the-fact" SIL's construction of the 11,404 foot rail line, and whether to authorize "after-the-fact" SIT's lease and operation of the same rail line as a common carrier. If the Board authorizes both actions, SIL and SIT would be able to operate the previously constructed rail line as a common carrier rail line and would be required to provide rail service to any shipper within the SGIH upon reasonable request.

2.2.1 Construction

The constructed rail line is approximately 11,404 feet in length. The eastern terminus of the Line connects with CSXT, near CSXT milepost S484.0. The Line extends in a westerly direction approximately 2.15 miles to its western terminus, a connection with NSR, near NSR milepost 16.6. (see **Figure 1-1**). Construction of the Line required crossing McCall Road, which was accomplished with the construction of an at-grade crossing with passive warning devices (stop

[12] See Savannah Industrial Transp., LLC—Operation Exemption—In Effingham Co., Ga., FD 36489, slip op. at 3 (STB served May 28, 2024).

signs and crossbucks) that comply with the *Manual on Uniform Traffic Control Devices* (FHWA, 2025).

In this Draft EA, OEA uses the following terms to describe the area where construction occurred and where operation of the Line occurs.

Rail line footprint. The rail line footprint includes the area of the railbed, as well as other physical structures installed during construction of the Line, such as the SGIH rail yard (consisting of three tracks, spaced 15 feet apart from centerline, with two tracks to the south and one track to the north of the Line), an access road (extending the entire length of the Line), and a ballast walkway. Rail operations occur in the rail line footprint.

Temporary footprint. The temporary footprint is the area that was temporarily disturbed during construction. The temporary footprint was reclaimed and revegetated following construction.

Project footprint. The project footprint is the combined area of the rail line footprint and temporary footprint, both of which were disturbed during construction.

Because the Line has already been constructed, OEA estimated the area of disturbance that resulted from construction of the Line. **Table 2-1** provides the length and area of the rail line footprint, temporary footprint, and project footprint.

Table 2-1 Length and Footprints from Construction of the Line

Length (feet)	Rail Line Footprint (acres)	Temporary Footprint (acres)	Project Footprint (acres)
11,404	15.6	25	40.6

Construction of the Line required removal of vegetation, clearing, and grading. Once the grading was completed, eight-inch subballast and eight-inch ballast layers were placed to create an approximately 24-foot-wide rail bed. Eight-foot by six-inch wooden rail ties and rails were then placed to form the Line. An access road, approximately 12-feet wide, was constructed of compacted ballast material for maintenance and inspection of the Line. A 320-foot long and 10-foot wide ballast walkway was constructed from the eastern terminus of the access road to the Sweigoffer Creek bridge for inspection and maintenance of the bridge. Staging areas used during construction were located in upland areas (United States Army Corps of Engineers (USACE), Permit No. SAS-2003-20390).

The Line and access road required crossing Willowpeg Creek and 8 other unnamed drainages during construction. Culverts were placed at 18 sites at various locations along the Line to cross drainages or provide drainage (OmniTRAX, Construction Drawings).

As previously noted, construction of the SGIH has continued independent of the rail line.[13] According to the SGIH website and conceptual plan, the SGIH development is divided into four areas. Area 1 is between the CSXT line and McCall Road. Land south of the Line in this area has

[13] SGIH is a 2,600-acre multimodal logistics park with active development underway. As part of the Georgia Ready for Accelerated Development (GRAD) Program, SGIH offers sites of various sizes and configurations that are fast-tracked for construction.

been developed, and current tenants of the SGIH are located here, including the current shipper. Area 2 is between McCall Road and the NSR line. The land east of the Line has been cleared and graded and was being prepared for construction during OEA's June 2024 site visit. Area 3 is between the NSR Line and Effingham Parkway (which is currently under construction). During OEA's site visit, vegetation removal was actively occurring in this area, with most of it already removed. Area 4 is between Effingham Parkway and Hodgeville Road. At the time of OEA's site visit, no development was occurring. See Map in **Figure 2-1** below.

2.2.2 Operation and Maintenance

OmniTRAX states that the Proposed Action would maintain and enhance competition among carriers and with other transportation modes. According to SIL and SIT, SIT currently transports 5,500 railcars per year, which could expand to up to 20,000 railcars in the next five years depending on the SGIH tenants and their demand for rail transportation by the end of the Board's forecast year (2029).[14] With the availability of common carrier freight rail service, SIL and SIT would be able to add additional shippers beyond the current existing shipper authorized by the Board.

As noted above, OmniTRAX states that current operations consist of two trains totaling four movements per day that interchange with CSXT and NSR. If the Board authorizes the Proposed Action, SIT estimates the existing rail traffic on the Line would increase by two trains per day (to a total of four trains, eight movements per day) by 2029.

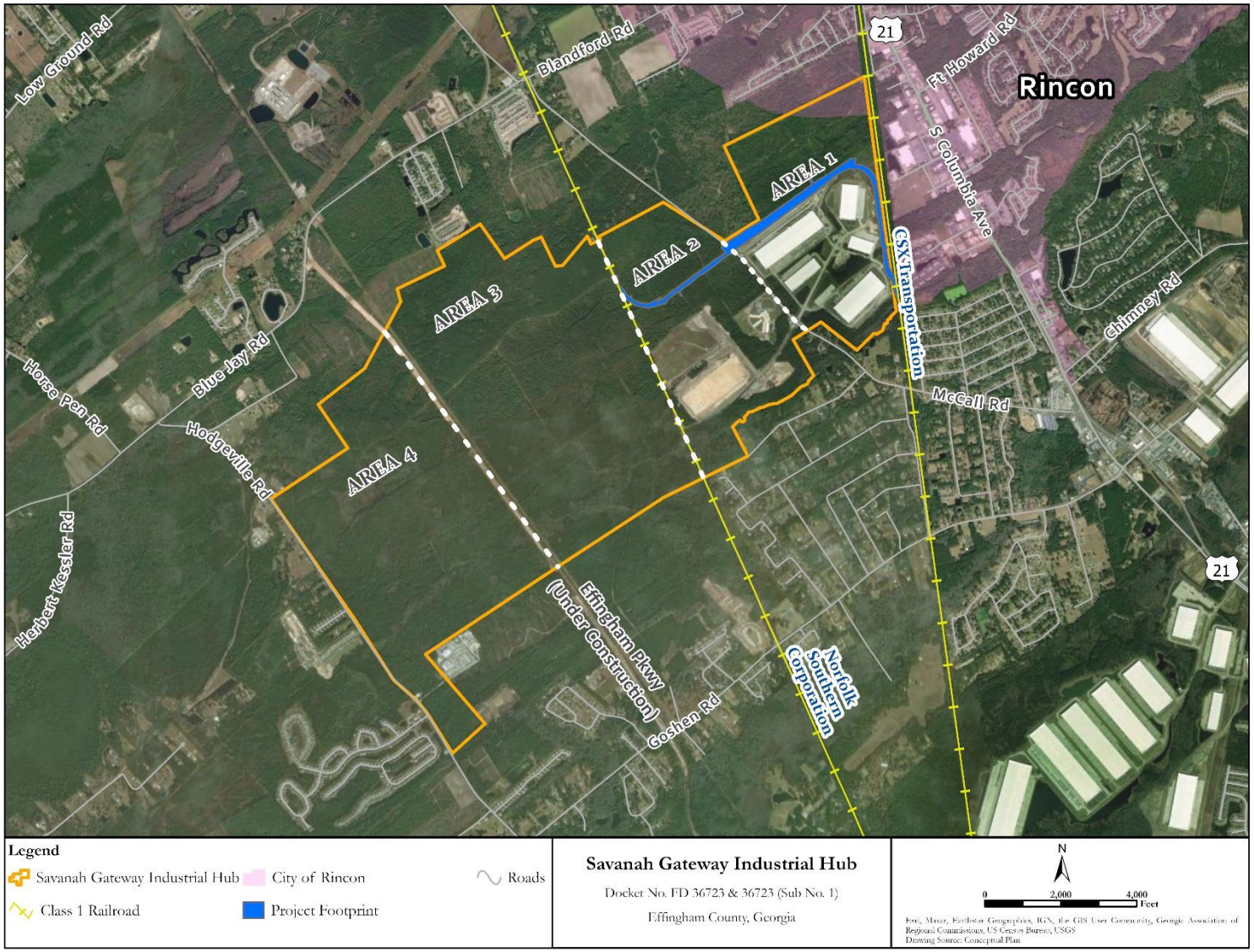
SIT projects the annual gross tonnage by 2029 to be approximately 2,345 thousand tons inbound to the SIT yard and approximately 640 thousand outbound towards either NSR or CSXT, an increase of approximately 335 percent over the current annual gross tonnage.

2.3 No-Action Alternative

Under the No-Action Alternative, the Board would not authorize "after-the-fact" SIL's construction of the Line, nor would the Board authorize SIT to lease and operate as a common carrier on the same track. Without the requisite Board authority, rail service on the Line would cease, thus no trains would operate on the Line. The current shipper served by SIT would lose access to rail service within the SGIH. Since the Line has already been constructed, the track would remain in place. While the only at-grade crossing located on the Line at McCall Road would remain in place, traffic on McCall Road would not be delayed due to train traffic because no trains would be operating on the Line.

[14] The Board uses a 5-year forecast to estimate changes in rail traffic.

Figure 2-1 Savannah Gateway Industrial Hub



Chapter 3
Affected Environment and Environmental Impacts

This chapter describes the affected environment, estimates the impact of construction of the Line in 2020, where possible, and evaluates the potential impacts from the Line's continued operation (Proposed Action) or cessation of operations (No-Action Alternative) for each resource. OEA analyzed the environmental resource areas set forth in the Board's environmental regulations at 49 C.F.R. § 1105.7(e).

OEA took the following steps to analyze each resource:[15]

- Reviewed regulations and guidance relevant to each resource, which are described in applicable sections.
- Defined a study area or study areas to be analyzed.
- Developed analysis approaches.
- Reviewed the current conditions of the resource in the relevant study area(s).
- Analyzed the potential impacts that the Proposed Action and No-Action Alternative would or could have on the resource.
- Identified mitigation that would minimize or compensate for impacts, if warranted.

OEA will make its final environmental recommendations to the Board, including its final recommendations on mitigation, in the Final EA, after considering agency and public comments on the Draft EA. The Board will consider OEA's final recommendations when deciding whether or not to authorize the Proposed Action – after-the-fact SIL's construction of the 11,404 foot rail line, and after-the-fact SIT's lease and operation of the same rail line as a common carrier.

3.1 Transportation and Safety

This section addresses existing rail and transportation conditions as well as impacts that could have resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. McCall Road is the only at-grade crossing within the project footprint, which includes the total area of disturbance (temporary and permanent) from construction of the Line (see **Section 2.2.1**). The subsections below provide a summary of the traffic analyses used, including the study area, data sources, and methods used to analyze the impacts, as well as the affected environment, including the estimated impacts of construction and the potential impacts of continued rail operations on vehicle safety and delay. The full analysis, including assumptions and calculations, for this analysis are included in **Appendix B**.

3.1.1 Approach

OEA defined the study area for this analysis as the at-grade crossing at McCall Road. The operational traffic analysis evaluated the at-grade crossing at McCall Road: under the current

[15] OEA used the best available data to inform its analyses. These data may not reflect all recent changes in conditions that have taken place due to the rapid development in the project vicinity.

scenario (2024) and under the future scenario (2029) for the No-Action Alternative and the Proposed Action.

The current scenario represents road traffic conditions that existed in the year 2024. The roadway traffic volumes were developed assuming a 2 percent annual growth rate from the 2020 base year used in the Lowe Engineers Savannah Gateway Traffic Impact Study prepared on August 30, 2019. (Note: Although referred to as 2020 volumes, they were determined based on 2019 counts and were not impacted by Covid related traffic reductions.)

The future scenario represents future conditions in the year 2029. The future 2029 Proposed Action and No-Action scenarios reflect no changes in roadway or railroad geometrics. The McCall Road grade crossing remains in place. Roadway traffic volumes are assumed to increase by 2 percent per year from 2024 to 2029 under both scenarios.

The grade crossing delay analysis includes two general components: one focused on individual train crossings and one focused on cumulative events over an entire day. The performance measures for individual train crossings include blocked crossing time per train, crossing delay per stopped vehicle, and maximum vehicle queue. The performance measures for cumulative events over an entire day include the number of vehicles delayed per day, average delay for all vehicles, and level of service (LOS) for vehicular traffic. For simplicity, it is assumed that both rail and road traffic are uniform throughout the day using the average daytime hour.

LOS is a qualitative measure of motor vehicle traffic flow, indicated by letters from A to F, where A represents free flow conditions and F indicates extreme congestion. OEA calculated estimated delay time using the industry standard equations set forth in **Appendix B**, which include the following variables: Average Annual Daily Traffic (AADT), train speed, train length, number of trains per day, number of railroad tracks, and number of roadway lanes. The average delay per vehicle is used to assign an LOS based on the standards shown in Error! Reference s ource not found. below.

Table 3-1 LOS Thresholds and Standards[16]

LOS	Average Delay per Vehicle (sec/veh)	General description
A	DV < 10	Free flow
B	10 < DV < 20	Stable flow (slight delays)
C	20 < DV < 35	Stable flow (acceptable delays)
D	35 < DV < 55	Congested flow nearing capacity
E	55 < DV < 80	Unstable flow, slightly over capacity
F	80 < DV	High level of delays & queuing, forced flow

[16] Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis. (Transportation Research Board 2016) Note: LOS criteria shown was developed and is used for traffic signals based on average delay per vehicle during peak hour of operations. Same criteria table is used for grade crossings based on average delay per vehicle over 24 hours.

OEA specifically considered the impact of delays on emergency vehicles as well. In addition to delay, OEA considered site-specific conditions, including the current road network, alternative routes available, and the locations of nearby emergency service stations (see **Appendix B**).

3.1.2 Affected Environment

For the transportation analysis in this Draft EA, OEA calculated current AADT levels as 5,990 vehicles per day using the 2020 base year with a two percent annual growth rate. The current tracks support a single shipper within the SGIH, served by two trains with 10 rail cars each per day or 5,500 railroad cars per year. Rail traffic is split evenly between CSXT and NSR with only half of SIT trains, or one train per day, needing to cross McCall Road. No electronic warning devices exist at the grade crossing. Using Federal Railroad Administration (FRA) methodologies and equations, OEA determined that current average daytime hour delays total approximately 1.3 minutes per vehicle on McCall Road. Average blocked time for emergency vehicles was determined to be 2.6 minutes per crossing event.

3.1.3 Environmental Consequences

As explained below, construction of the Line likely resulted in impacts to transportation delay and safety due to the movement of construction equipment, materials, and workers. Continued operation of the Line under the Proposed Action would result in minimal impacts to transportation and safety. Under the No-Action Alternative, potential impacts would decrease as no trains would operate on the Line.

Construction

The McCall Road at-grade crossing is the sole at-grade crossing created by the Line's construction. The crossing is located directly west of the auxiliary tracks associated with the Line. The number of mainline tracks at the crossing is one track and the number of roadway lanes at the crossing is two lanes. Prior to construction of the Line, two studies were conducted as part of the development of the SGIH property 1) in 2010 and 2) in the previously referenced the Traffic Impact Study in 2019.

The traffic impact study conducted in 2019 considered two traffic scenarios as part of the analysis: traffic without the project and traffic with the project. The future year scenarios considered the opening year for the project (2020) and used 2019 traffic counts projected to year 2020. This study determined that delays by project-generated trips were expected to be minimal, with traffic operations at McCall Road determined to have an LOS of A or B.

Although the Line has already been constructed, construction likely required trips for the movement of materials, equipment, and workers to and from work sites, construction staging areas, and construction camps. These construction-related vehicle trips could have increased vehicle delays on local roadways. A temporary complete closure of McCall Road also likely occurred to accommodate construction of the at-grade crossing. The level of impact would have depended on the increase in construction vehicle traffic and the available capacity of the roadways in the project study area and larger transportation system. In addition, some temporary delays could have occurred on portions of existing roads during construction due to temporary road closures required for the construction of the at-grade crossing.

School traffic times at Blandford Elementary School, located directly west of McCall Road, occur Monday through Friday from 7:00 to 8:00 AM and 2:20 to 3:00 PM. Therefore, school traffic may have been disrupted and delayed due to construction-related vehicle trips.

Operations

SIT estimates that, if the Board authorizes the Proposed Action, the current rail traffic on the Line would increase by two trains per day (to a total of four trains, eight movements per day), or twenty trains per week, by 2029. Because SIT only crosses the at-grade crossing to service cars from the NSR line to the west, OEA assumed that only half the total number of trains would serve the NSR line. Therefore, OEA analyzed ten trains per week (or two trains per day) for the 2029 future scenario.

Although NSR delivers cars on Saturdays rather than Mondays, OEA assumed that rail crossings necessitating stops on McCall Road would occur on weekdays during daylight hours only, a period that reflects higher traffic volumes and therefore conservatively provides a higher estimate of demand. OEA assumed that, on average, 8 percent of the total daily traffic occurs during the peak hours. While current operations indicate that trains reach a maximum of approximately 10 miles per hour at the McCall Road crossing, OEA used 5 miles per hour for a more conservative approach. OEA's methodology, including a full list of assumptions can be found in **Appendix B**.

To estimate train length, OEA used information regarding rail volume received from SIL and SIT. SIT projected an increase in rail car volumes from 5,500 carloads in 2024 to 20,000 carloads in 2029.

Based on the information provided by SIL and SIT, SIT's continued operation of the Line under the Proposed Action would most likely result in 20 long trains crossing the at-grade crossing at McCall Road per week with a length of 20 cars per train.[17]

A summary of the railroad operations and assumptions for the current (2024) and future (2029) scenarios is shown below in **Table 3-2**. The No-Action Alternative scenario is not reflected in this table, as rail operations would cease under this scenario. The analysis focuses on the impact of a single rail crossing event and does not depend on the volume of vehicular traffic on McCall Road or the number of trains.

Table 3-2 Rail Volumes and Operational Impacts of Single Train Crossing of McCall Road

Year	Description/ Assumptions	Rail Carloads per Year	Trains per Week	Average Length of Train (# of cars)	Length of Train (ft) - assumes 75 ft per car + 100 ft locomotive
2024 Current: QUANTIX in Current Stage: Est. 5,500 Rail Cars Per Year					
2024	data computed	5,500	10	10.6	893
Proposed Action QUANTIX & 3 Additional Companies: Up To 20,000 Rail Car Loads Per Year					
2029	20 trains/week	20,000	20	19.2	1,542

[17] (Aug. 29, 2024) (Env't Comment EI-33619), FD-36723 and FD-36723 (Sub-No. 1).

Using information provided from OmniTRAX and the assumptions to estimate train length from **Table 3-2**, OEA calculated delays over an entire day (24 hours).[18] **Table 3-3** below shows the impacts of SIT's continued operation of the Line under the Proposed Action (20 long trains per week) for events over an entire day (24 hours) and the corresponding LOS. OEA anticipates LOS A for 2029 operations based upon average daily delay per vehicle of 2.7 seconds per vehicle. Therefore, impacts on the roadway system for the Proposed Action scenario would be minimal.

Table 3-3 Proposed Action Total Crossing Delay per Vehicle and Level of Service for 24 Hour Standard

Year	Description/ Assumptions	Average Length of Train (cars)	Delays and LOS over 24 Hours (Required Rail Crossing Measure & Comparison)			
			Total Crossing Delay (min/day)	Average Vehicles per Day (vpd)	Average Delay per Vehicle in 24 hours (sec/veh)	LOS over 24 hours
2024	data computed	10.6	59.8	5,990	0.6	A
Proposed Action QUANTIX & 3 Additional Companies: Up To 20,000 rail cars per year						
2029	20 trains/week	19.2	321.7	7,159	2.7	A

OEA also considered the potential impacts of continued operation of the Line under the Proposed Action on potential emergency vehicle delays. OEA conducted an analysis of emergency response time if the McCall Road crossing were closed, or if an emergency response vehicle arrived at the crossing at the same time a train began crossing and was forced to wait. In 2029, the blocked crossing time is estimated to be 4.1 minutes (with approx. 20 cars/train). Although unlikely, OEA also analyzed a scenario where an emergency incident causes a closure at the crossing itself, forcing vehicles to travel a different route. This analysis is summarized in **Appendix B, Table 9**.

Coordination with GDOT, local transportation agencies and the Blandford Elementary School likely occurred during the construction of the at-grade crossing warning devices. For the rare and unpredictable events that could stop a train and result in a blocked crossing, there are already Emergency Notification Systems signs at the at-grade crossing. The sign includes a toll-free phone number to contact the railroad. FRA provides guidance and resources to law enforcement and first responders on what to do in the event of an emergency at an at-grade crossing, such as a stopped train. Examples include:

1. Contact the railroad responsible for the track,
2. Determine if the incident involves a trespasser or a motor vehicle, and
3. Determine if there are additional dangers such as a motor vehicle on the track or hazardous cargo.

FRA recommends that law enforcement and emergency responders become familiar with the railroads operating in their jurisdiction, including the types of products regularly transported.

[18] Id.

Further, FRA recommends that emergency dispatchers develop a policy for handling railroad incidents and maintain a map of all railroads and crossings in the area.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts beyond what has already been described in the construction subsection above. Under the No-Action Alternative, rail service on the Line would cease, and there would be fewer impacts to grade-crossing delay and safety.

3.1.4 Conclusion

Construction of the Line likely had temporary impacts to vehicle delay. Additionally, OEA concludes that impacts to grade crossing delay would be negligible, while emergency vehicle delay would have a minor impact to transportation and safety as a result of the continued operation of the Line under the Proposed Action. Continued operation of the Line over a 24-hour period would have no impact as delays would continue to reflect LOS A operations over 24 hours. Therefore, OEA concludes that minimal impacts would occur to transportation and safety due to the potential emergency vehicle delay.

3.2 Land Use, Zoning, and Local Plans

This section describes the impacts on land use, zoning, and local plans that could have resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. Land uses considered in this analysis include land use patterns, land use plans and authorizations, and designated recreational areas. The subsections that follow describe the study area, methods used to analyze the impacts, the affected environment, and the impacts of the Proposed Action and No-Action Alternative on land use.

3.2.1 Approach

OEA reviewed documents provided by SIL and SIT related to the previous development and construction of the Line. Additionally, OEA reviewed the Effingham County 2020-2040 Joint Comprehensive Plan, and site plans and local zoning maps for Effingham County and the City of Rincon. The existing land uses were documented through field observations and land use maps. A list of documents provided by SIL and SIT used to evaluate impacts to land use are provided below:

- Development of Regional Impact Findings Report prepared by the Coastal Regional Commission (CRC) of Georgia for Effingham County dated July 5, 2012,
- Effingham County Development Plan Review Application completed by Savannah Industrial District dated March 19, 2020, and
- Site Development Plans for SGIH first submittal for Effingham County Review dated May 15, 2020.

To assess the potential impacts related to land use associated with the Proposed Action and the No-Action Alternative, OEA defined the study area as the project footprint, which includes the total area of disturbance (temporary and permanent) from construction of the Line (see **Section 2.2.1**) located within an unincorporated area of Effingham County, bordering the City of Rincon to the west.

3.2.2 Affected Environment

At the time of the 2012 Regional Impact Findings Report, the zoning of the SGIH property was residential mixed use (PD-R) and planned development (PD). Effingham County then amended the zoning of the property to industrial use (I-1) in 2012.[19] Surrounding properties were largely considered developed, and a location along Blue Jay Road directly north of the SGIH property was identified as an 'area of significant infill opportunity,' where new construction could occur. Adjacent properties to the north and south of the SGIH were designated as agricultural (AR-1),[20] with some considered undeveloped and residential.

The study area is located between two Class I rail lines within the SGIH in an unincorporated area of Effingham County and is characterized as primarily rural. The SGIH, including the study area, is zoned Light Industrial (I-1) **(**see **Figure 3-1**). Effingham County defined Light Industrial (I-1) zoning in the 2020-2040 Joint Comprehensive Plan (October 2019) as:

> "…land dedicated to manufacturing facilities, processing plants, factories, warehousing and wholesale trade facilities, mining or mineral extraction activities, or other similar uses" and "land dedicated to transportation and utilities uses. It can accommodate transportation infrastructure and public and private utilities including but not limited to, power lines, water and wastewater facilities, electrical substations."[21]

As part of Effingham County's Comprehensive Plan, the county classified the SGIH as I-1 because it was looking to "promote the expansion of job opportunities, high quality industry and diversification of the employment base to help the county grow beyond a bedroom community and to establish itself as a place to do business." Furthermore, the county was looking to "implement and expand economic development plans to diversify the county economy and promote the recruitment of high-quality commercial industrial businesses."

The area to the east of the Line is part of the City of Rincon and zoned as General Commercial (B-2).[1] The B-2 zone permits business and professional offices, mixed-use residential, institutional uses, and retail business. No commercial outdoor storage businesses are permitted in this zone.

The nearest residence (Effingham Parc Apartments) is located approximately 200 feet east of the CSXT rail line (see **Figure 3-2**). The nearest recreation site, Freedom Park, is approximately 350 feet from the study area, separated from the Proposed Action by the CSXT rail line. The Proposed Action includes one at-grade crossing, which is located at McCall Road. Blandford Elementary School is located approximately 1,400 feet from this at-grade crossing.

[19] This zoning is consistent with the Effingham County 2020-2024 Joint Comprehensive Plan.

[20] Effingham County Zoning Ordinance (https://library.municode.com/ga/effingham_county/codes/code_of_ordinances?nodeId=PTIIOFCO_APXCZOOR_ARTIVESDI).

[21] Effingham County 2020-2040 Joint Comprehensive Plan, pages 28-29, October 2019.

Figure 3-1 Zoning Map

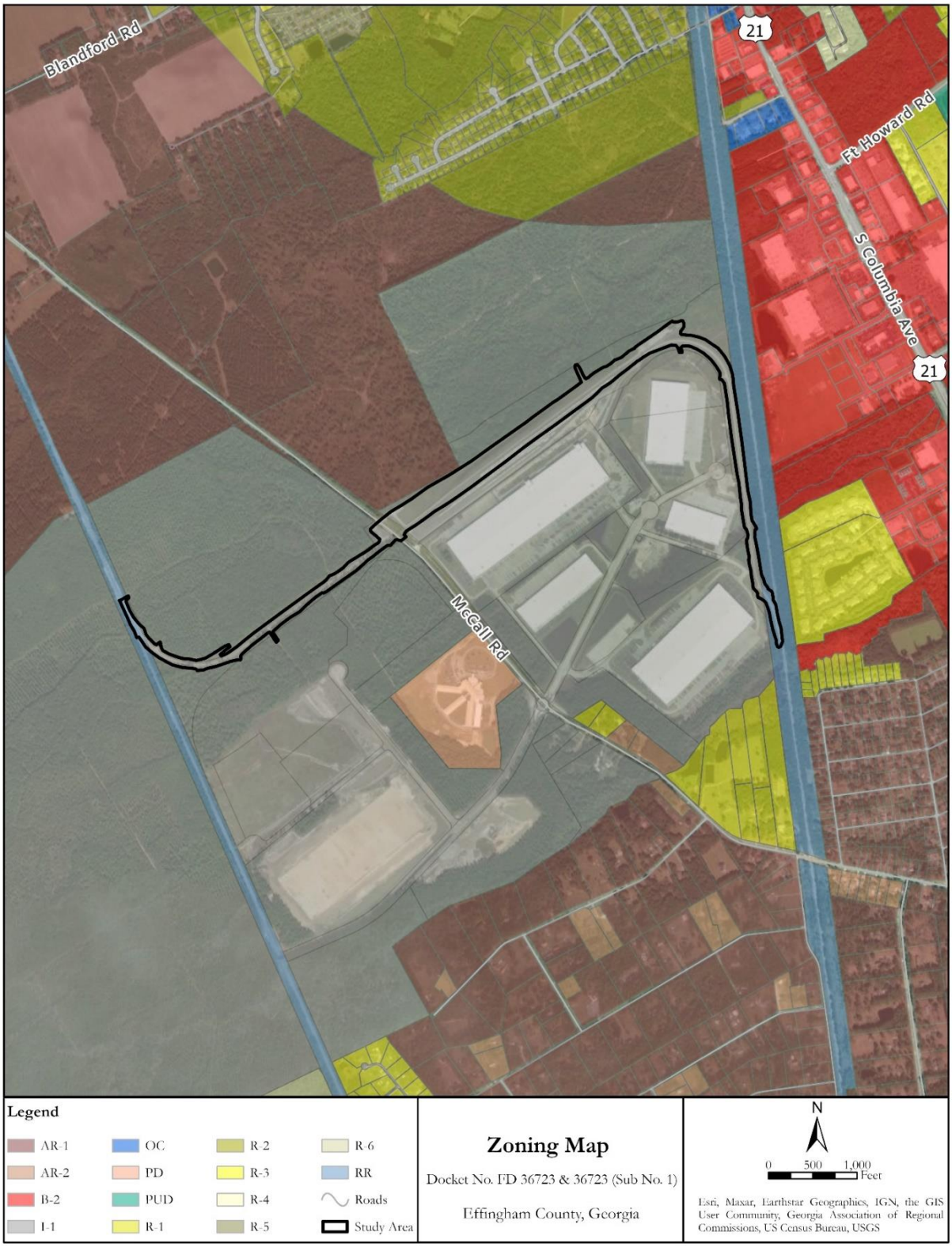


Figure 3-2 Nearest Residence, Park, and School



3.2.3 Environmental Consequences

Construction of the Line appears to have been consistent with Effingham County's land use, zoning, and local plans. The same is true for SIT's projected rail operations. Under the No-Action Alternative, there would be no SIT rail service, and the study area would continue to be zoned Light Industrial (I-1).

Construction

As noted above, zoning was changed from PD-R and PD to I-1 to accommodate the planned SGIH property. Therefore, construction of the Line did not alter existing zoning and land designation. Additionally, there were no residential or business displacements as a result of construction of the Line. While the construction resulted in the loss of vegetation and potential habitat, it appears to have been consistent with land use, zoning, and local plans, as the area is zoned for light industrial use.

Operations

The Proposed Action within the I-1 zoning district would continue to be consistent with local zoning. Furthermore, the Proposed Action would continue to promote Effingham County's Comprehensive Plan goals of expanding economic development by maintaining the railroad for local businesses. The surrounding land uses are not anticipated to change due to the Proposed Action.

No-Action Alternative

Under the No-Action Alternative, the Board would not authorize the after-the-fact rail construction and operation. Without the requisite Board authority, rail service on the Line would cease, and no trains would operate on the Line. The land use of the study area would continue to be consistent with the zoning district (I-1).

3.2.4 Conclusion

As discussed above, OEA concludes that based on a review of land use and zoning in Effingham County and the City of Rincon, the Proposed Action would not result in impacts to zoning and land use. The Proposed Action is consistent with the comprehensive plan of Effingham County.

3.3 Energy

This section describes the potential impacts that could result from the continued operation of the Line. The study area, data sources, and approach used to analyze potential impacts are described below. The Board's environmental regulations, 49 C.F.R. § 1105.7(e)(4), require an evaluation of potential impacts on transportation of energy resources, recyclable commodities, and the increase or decrease in energy efficiency.

3.3.1 Approach

OEA defined the study area for energy resources as the Line, within the greater SGIH boundary and Effingham County. OEA did not analyze energy effects from construction because the capacity to increase or decrease energy efficiency does not occur during construction. OEA also does not expect the Proposed Action to result in the transport of energy resources or recyclable

commodities by rail, nor does OEA expect the Proposed Action to cause any diversion of freight from rail to trucks, so that was also not evaluated in this Draft EA.

OEA evaluated the change in energy use due to rail operations. Energy consumption for continued operation of the Line includes diesel fuel for locomotives, fuel for personnel vehicles, and electricity for powering communications equipment and other rail-related equipment.

3.3.2 Affected Environment

The affected environment encompasses the Line and its rail operations. Two main electricity suppliers serve Effingham County: Georgia Power and Planters Electric Membership Cooperation. Based on a desktop review and site visit by OEA, there are no visible transmission lines on the SGIH property.

3.3.3 Environmental Consequences

Operations

Under the Proposed Action, continued operation of the Line would require diesel fuel for the locomotives. Additionally, during rail operations, vehicle and system-wide equipment directly related to moving commodities via rail would consume energy. The primary fuel source for rail operations is diesel fuel. One gallon of diesel fuel is equivalent to approximately 144,945,000 joules, a unit of energy (U.S. Energy Information Administration 2023). The estimated changes in energy efficiency are measured in million joules (MJ). It is expected that the energy demand for communications and safety equipment would be negligible in comparison to the existing rail operations. Under the Proposed Action, energy usage would be approximately 2,824,864 MJ per year (approximately 19,402 gallons of diesel per year) due to the increase in locomotive usage from existing conditions. The consumption of diesel would increase by 2029 under the Proposed Action due to the anticipated increase in train traffic. However, the energy network should be able to accommodate this additional need.

Additionally, there would be an increase in fuel usage from vehicles idling at railroad crossings. Assuming most vehicles would be gasoline-fueled sedans, the estimated gasoline consumption per vehicle during idle would be 0.39 gallons of gasoline per hour (U.S. Department of Energy 2015). Under the Proposed Action, energy usage would be approximately 100,657 MJ per year (approximately 763 gallons of gasoline per year), per the total daily delay provided in **Section 3.1**.

No-Action Alternative

Under the No-Action Alternative, operation of the Line would cease. However, the No-Action Alternative would cause diversions from rail to truck, increasing the need for energy consumption of diesel fuel for trucks. The estimated energy usage from rail-to-truck transportation would be approximately 5,591,230 MJ (approximately 38,402 gallons of diesel per year).

3.3.4 Conclusion

Because the energy network can accommodate the increases in fuel usage for the diesel locomotives, car idling, and increased truck usage for the Proposed Action, OEA concludes that the Proposed Action would result in negligible impacts to energy resources. Under the No-

Action Alternative, terminating the Line's operation would reduce electricity consumption but increase diesel fuel usage, as transportation shifts from rail to trucks. OEA concludes that this transition would result in negligible impacts to energy resources.

3.4 Air Quality

This section describes impacts on air quality that could have resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. The study area, data sources, and approach used to estimate impacts to air quality from construction of the Line and its continued operation are described below.

3.4.1 Approach

OEA defined the study area for air quality as Effingham County. The Environmental Protection Agency (EPA) classifies each county in the U.S. as being in "attainment" or "nonattainment" for each criteria pollutant. A county is in attainment for a specific pollutant when the pollutant concentration is below the National Ambient Air Quality Standards (NAAQS). A county is in nonattainment for a specific pollutant when the pollutant concentration exceeds the NAAQS. Some nonattainment pollutants (such as ozone, CO, and PM_{10}) are further classified by the degree to which they exceed the NAAQS. For ozone, these classifications rank in severity in the order of "Marginal," "Moderate," "Serious," "Severe," and "Extreme." A county can be in attainment for some pollutants and in nonattainment for other pollutants. A third category, "maintenance area," is an area that was formerly in nonattainment but has reduced pollutant concentrations to be in attainment of the NAAQS. EPA bases its attainment status designations on ongoing air monitoring studies and the number of times specific criteria pollutants exceed NAAQS. EPA uses a fourth category, "unclassifiable," for areas with insufficient data to make an attainment determination. EPA treats unclassifiable areas like attainment areas. As discussed below in **Section 3.4.2**, the Effingham County region is in attainment for all criteria air pollutant NAAQS.

For actions necessitating a detailed air quality analysis, OEA assesses action-related emissions as the change to criteria air pollutants resulting from a Proposed Action. These changes are the difference between emissions under the Proposed Action compared to emissions under the No-Action Alternative. OEA quantitatively evaluates air emissions using EPA emission standards for locomotives (EPA 2009).[22] Due to the increase in gross ton miles annually of at least 100% as a result of the Proposed Action, the following detailed air quality analysis is presented.

In this Draft EA, OEA specifically estimated air pollutant emissions of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs)—evaluated as precursor compounds for the formation of the criteria pollutant ozone (O_3), which is not directly emitted by combustion sources—and of criteria pollutants carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter (PM), including PM with a particle diameter less than or equal to 10 microns (PM_{10}) and PM with a particle diameter less than or equal to 2.5 microns ($PM_{2.5}$).

[22] Environmental Protection Agency (EPA). 2009. *Technical Highlight – Emission Factors for Locomotives*. Accessed: September 16, 2024. Available: https://nepis.epa.gov/exe/zypdf.cgi?Dockey=p100500b.pdf.

3.4.2 Affected Environment

Table 3-4 presents the attainment status of Effingham County, Georgia. As noted above in **Section 3.4.1** Effingham County is in attainment; therefore, EPA's conformity regulations would not apply to federal actions in the region. Moreover, the Board does not exercise continuing program control over rail operations and would not exercise such control over operation of the Proposed Action. Accordingly, the Proposed Action would not be subject to General Conformity.

Table 3-4 NAAQS, Effingham County, Georgia

Standard	Attainment Status
8-Hour Ozone (2015)	Attainment
PM2.5 (2012)	Attainment
PM10 (1987)	Attainment
Sulfur Dioxide (2010)	Attainment
Lead (2008)	Attainment
Carbon Monoxide (1971)	Attainment
Nitrogen Dioxide (1971)	Attainment

Source: NAAQS

3.4.3 Environmental Consequences

Construction of the Line likely resulted in negligible impacts to air quality, and operation of the Line would not result in adverse impacts to air quality. Under the No-Action Alternative, impacts to air quality would decrease.

Construction

Construction equipment, trucks, and workers' personal vehicles likely emitted diesel and gasoline exhaust, which contain various air pollutants, including CO, NO_X, and PM. Excavation and earthmoving activities, vehicle and equipment movement over unpaved roads and surfaces, and wind erosion of exposed soil and materials could have emitted fugitive PM, including small particles (PM_{10} and $PM_{2.5}$) that could have impacted air quality and human health. However, any emissions from construction activities would have been temporary and likely would have occurred only where construction took place or along roads traveled by construction vehicles. The exact effects of construction emissions on ambient air quality also would have been dependent on the construction schedule, the mobility of the emission sources, the types of equipment in use, and local meteorology at the time of construction.

Operation

Under the Proposed Action, operations are projected to increase by two trains per day, from two trains and four movements per day to a total of four trains and eight movements per day by 2029, the analysis year for this Draft EA. Based on information provided by SIL and SIT, OEA assumed an average train speed of 10 miles per hour on the 11,404-foot previously constructed rail line. SIT's switch operations use one 1,500 horsepower Tier 0 EMD GP9 locomotive.

SIT expects that new shippers could use SIT's freight services on the Line.[23] Annualized activity is expected to reach 20,000 railroad cars in 2029. Anticipated daily train activity is expected to be twice that of the existing conditions and would involve two switch crews handling an average of eight daily movements (four inbound and four outbound), five days per week. Based on 2024 inbound gross tonnage of 715,000 tons and outbound gross tonnage of 176,000 tons over 5,500 carloads, an assumed loaded railcar weight of 100-110 tons, and an assumed empty railcar weight of 28-33 tons, it is anticipated that the projected annual 2029 gross tonnage would be 2,345,000 tons inbound and 640,000 tons outbound under the Proposed Action.

Table 3-5 presents the estimated 2029 annual emissions associated with rail operations under existing conditions and the Proposed Action. As shown in **Table 3-5**, the incremental increase in criteria pollutant emissions would range from <0.1 tons per year for SO_2 to 2.8 tons per year for NO_X.

Table 3-5 Estimated Criteria Air Pollutant Annual Emissions

Scenario	Emissions (tons per year)					
	CO	**VOC**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**
Existing Conditions, 2024	0.1	0.1	0.8	<0.1	<0.1	<0.1
Proposed Action, 2029	0.4	0.2	2.8	0.1	0.1	<0.1

Source: CDM Smith

During rail operations, locomotives would emit exhaust, which would affect air quality. Increased rail activity under the Proposed Action would result in a slight increase in air pollutants, such as CO, VOC, and NO_X. Increased idling of vehicles due to train operations would also contribute to vehicle exhaust emissions. OEA estimated the increase in vehicle delays based on the estimated delays discussed in **Section 3.1 Transportation System and Safety**. Based on the estimated increases in delay, OEA concluded that increases in exhaust emissions from idling vehicles at at-grade crossings under the Proposed Action would be unlikely to exceed the NAAQS. Therefore, the Proposed Action would result in no adverse impacts on air quality. The continued operation of the Line would also reduce exhaust emissions from trucks.

No-Action Alternative

Under the No-Action alternative, locomotive exhaust emissions would decrease because rail operations would cease. However, truck exhaust emissions would increase without a rail alternative to transport goods to and from the industrial park. Thus, OEA concludes that the No-Action alternative would likely result in impacts to air quality.

[23] On February 9, 2024, SIL and SIT filed a petition for clarification or other relief seeking Board authority to serve additional shippers including an aggregate transload facility operator (Conrad Yelvington), an unidentified transport company, and an unidentified logistics company during the pending construction and lease and operation proceedings, which the Board denied in a May 28, 2024 decision. In a more recent filing, SIT projected that the Line could serve three new shippers by 2029 including a steel coil receiver, a limestone terminal company, and an aggregate shipper (EI-33624, filed September 12, 2024).

3.4.4 Conclusion

During construction, equipment, trucks, and workers' personal vehicles likely emitted diesel and gasoline exhaust. Further, excavation and earthmoving activities likely emitted fugitive dust. However, any emissions from construction activities would have been temporary and have now concluded. Rail operations would result in increased emissions of criteria air pollutants. However, OEA anticipates that under the Proposed Action, the increase in emissions would not exceed the NAAQS. Therefore, OEA concludes the Proposed Action would have no adverse impacts to air quality. Under the No-Action alternative, there could be impacts to air quality from an anticipated increase in truck traffic.

3.5 Noise and Vibration

This section describes the impacts on noise that could have resulted from construction of the Line and potential impacts that could result from the continued operation of the Line. The study area, data sources, and approach used to estimate construction impacts and analyze the potential impacts of the Proposed Action and No-Action Alternative are described below.

3.5.1 Approach

OEA used well-established methods to analyze noise and vibration impacts associated with the Proposed Action and No-Action Alternative. See **Appendix C**, which details OEA's noise and vibration methodology and equations. OEA defined the study area for the noise and vibration analysis to be the area within approximately one-quarter mile to either side of the centerline of the Line. OEA determined that this study area distance, based on prior OEA experience, is sufficient to properly identify potential noise and vibration impacts from the Proposed Action. Regulations, statutes, and guidelines that specify requirements and provide guidance on the noise and vibration analysis and impact assessment for the Proposed Action include:

- The Board's environmental regulations at 49 C.F.R. §1105.7
- Noise Control Act of 1972 (42 United States Code [USC] 4910)
- National Environmental Policy Act (42 USC 4321-4370m-11)
- FRA Guidelines (Report Number 293630-1, December 1998)
- Occupational Safety and Health Administration (OSHA) Occupational Noise Exposure; Hearing Conversation Amendment (Federal Register [FR] 48 (46), 9738—9785)
- EPA Railroad Noise Emission Standards (40 C.F.R. Part 201)

Day-night average noise level (DNL): The energy average of A-weighted decibels (dBA) sound level over a 24-hour period; includes a 10-decibel adjustment factor for noise between 10 p.m. and 7 a.m. to account for the greater sensitivity of most people to noise during the night. The effect of nighttime adjustment is that one nighttime event, such as a train passing by between 10 p.m. and 7 a.m., is equivalent to 10 similar events during the daytime.

A-weighted decibels (dBA): A measure of noise level used to compare noise from various sources.

A-weighting approximates the frequency response of human hearing.

- FRA Railroad Noise Emission Compliance Regulations (49 C.F.R. Part 210)
- FRA Final Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings (49 C.F.R. Parts 222 and 229)
- Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment (FTA-VA-90-1003-06, May 2006)

Ambient noise: The sum of all noise (from human and naturally occurring sources) at a specific location over a specific time is called ambient noise.

The Board's environmental regulations for noise analysis (49 C.F.R. §1105.7e(6)) have the following criteria:

- An increase in noise exposure as measured by a day-night average noise level (DNL) of 3 A-weighted decibels (dBA) or more.
- An increase to a noise level of 65 DNL or greater.

If the estimated noise level increase at a location exceeds either of these above criteria, OEA estimates the number of affected receptors (e.g., schools, libraries, residences, retirement communities, nursing homes) and quantifies the noise increase. The two components (3 dBA increase or an increase to a noise level greater than 65 DNL) of the Board's criteria are implemented separately to determine an upper bound of the area of potential noise impact. However, noise research indicates that both criteria components must be met to cause an adverse noise impact (Coate, 1999[24], STB 1998b[25]).[26] That is, noise levels would have to be greater than or equal to 65 DNL and increase by 3 dBA or more for an adverse impact to noise to occur.

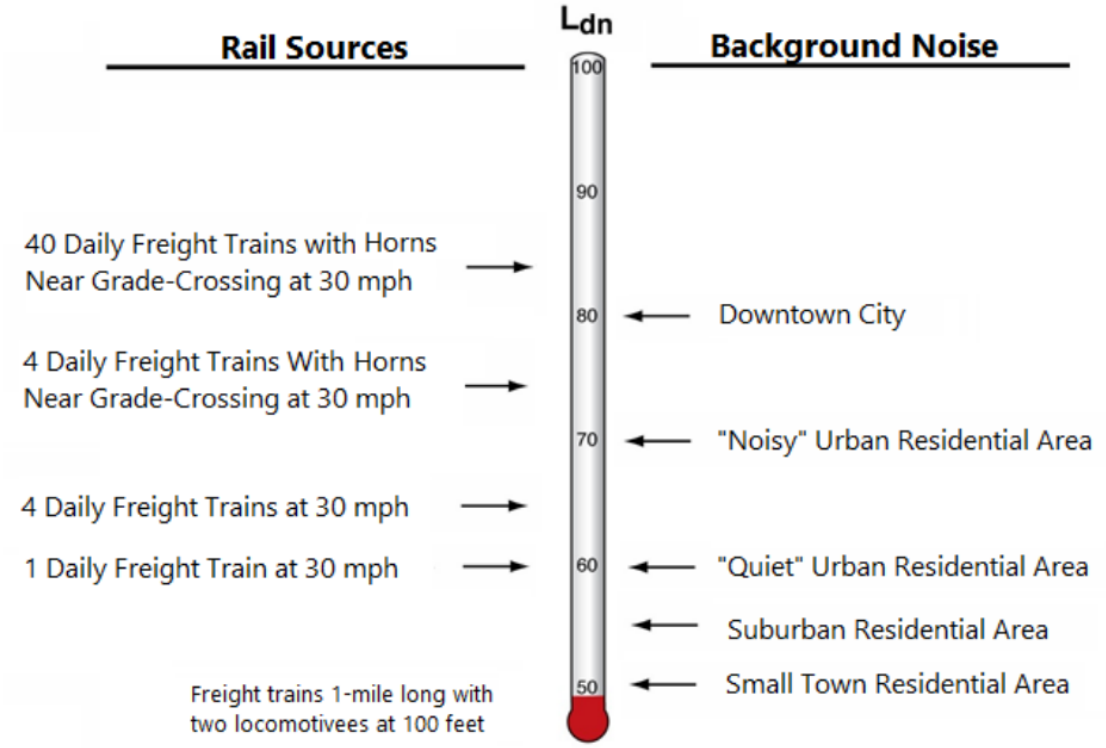
For this analysis, "Noise" is considered unwanted sound. Human perception of and response to a new noise source is based in part on how loud it is compared to existing/ambient noise levels. **Figure 3-3** presents the typical range of background DNL noise levels and typical noise DNL noise levels, generated by freight train activity at a distance of 100 feet from the tracks.

[24] Coate, D. 1999. Annoyance Due to Locomotive Warning Horns. Transportation Research Board Noise and Vibration Subcommittee A1FO4. August 1–4. San Diego, CA.

[25] Surface Transportation Board (Board). 1998a. Final Environmental Impact Statement No. 980194, Conrail Acquisition (Finance Docket No. 33388) by CSX Corporation and CSX Transportation, Inc., and Norfolk Southern Corporation and Norfolk Southern Railway Company (NS).

[26] Although the Board's regulations at 49 C.F.R. § 1105.7(e)(6) indicate that either an increase of 3 dBA or an increase to an DNL or Ldn of 65 dBA would be an adverse impact, research indicates that both of these conditions must be met or exceeded for an adverse noise impact from rail operations to occur.

Figure 3-3 Typical DNL (Ldn) Noise Levels



Source: Federal Transit Administration (FTA) 2018

3.5.2 Affected Environment

The study area for this analysis includes existing noise sources from the CSXT and NSR rail lines, the industrial development, vehicular traffic on McCall Road, and general human activity. The study area is located within the SGIH. Much of the area to the north and south of the rail line is undeveloped, forested land. The closest sensitive receptors to the study area include the Effingham Parc Apartments and Town Park Commons, two residential apartment complexes, located east of the CSXT line, and the Blanford Elementary School, which is located approximately 1,400 feet south of the project footprint. Because of this, the rail traffic is a dominant noise source in the study area. Existing noise levels are primarily within the "Quiet" range of residential categories.

Operations occur over the previously constructed track for a total of six days per week, typically occurring between 5:00 AM and 2:00 PM. Further details on existing train operations are provided in **Chapter 2**.

Using Computer Aided Noise Abatement (CadnaA), the leading environmental noise software application, OEA computed existing noise levels in the study area. OEA input site-specific data, such as existing roadway and rail alignments, into the model. OEA incorporated SIT's existing rail operations of approximately one round trip (one train, two train movements) five days per week to interchange with NSR and one round trip (one train, two train movements) five days per week to interchange with CSXT for a total of two trains per day, or two trains and four train movements total. Based on information provided by SIL and SIT, OEA assumed an average

speed of 10 miles per hour and an average train length of 720 feet, consisting of one locomotive and 10 freight cars. OEA modeled noise from the operation of locomotives and rail car wayside operations and horn noise on the Line during daytime hours. Currently, train horns are not used on the Line but were included in OEA's analysis to represent a worst-case scenario. The equations used to calculate noise levels are shown in **Appendix C**. OEA included estimated noise associated with the existing rail yard, such as noise from switch engines, car coupling, and other associated noise sources. Noise associated with CSXT and NSR and McCall Road were also incorporated into the noise model. OEA assumed that five freight trains with an average speed of 20 miles per hour occur on the CSXT and NSR lines per day. Amtrak's Palmetto line also currently uses the CSXT line. Therefore, OEA assumed that five Amtrak trains with an average speed of 49 miles per hour operate on the CSXT line. The speed limit at McCall Road is 45 miles per hour.

Figure 3-4 shows the results of the existing noise level modeling in the study area. The dark red contour lines are at 65.0 DNL. Based on this data, existing noise levels from the Line exceed 65 DNL at approximately 128 feet from the centerline of the Line when unaffected by other noise sources. No sensitive receptors are located within areas that exceed 65 DNL (the criteria set by 49 C.F.R. § 1105.7(e)(6) for adverse impacts). As the Blanford Elementary School is approximately 1,400 feet from the project footprint, the effects to the school from existing railroad noise are negligible. Noise levels near the Effingham Parc Apartments and Town Park Commons east of the project footprint are estimated to be 57.6 DNL at the closest location to the project footprint and are primarily caused by existing CSXT rail operations.

3.5.3 Environmental Consequences

Continued operation of the Line under the Proposed Action would increase the potential for noise impacts. However, due to the low number of additional trains per day and limited rail yard noise, operational noise impacts would not adversely affect sensitive receptors. The No-Action Alternative would remove rail-related sources of noise from the Line, which would result in decreased noise.

Construction

Construction of the Line likely resulted in construction-related noise impacts. However, OEA did not assess or model noise impacts resulting from construction of the Line because construction has already occurred. Moreover, any construction impacts that occurred were temporary. Accordingly, the analysis below analyzes only the noise impacts resulting from train operations.

Operations

Under the Proposed Action, the existing rail traffic on the Line would increase by two trains per day (to a total of 4 trains, eight movements per day) by OEA's 2029 forecast year. OEA used this projected traffic in its noise model for the Proposed Action. OEA assumed an average speed of 10 miles per hour and an average train length of 1,542 feet. OEA included estimated noise associated with the existing rail yard, which could be caused by switch engines, car coupling, or other associated noise sources. OEA assumed that operations associated with the NSR and CSXT rail lines and McCall Road would remain the same as under existing conditions.

Figure 3-4 Existing Noise Contour Levels in the Study Area

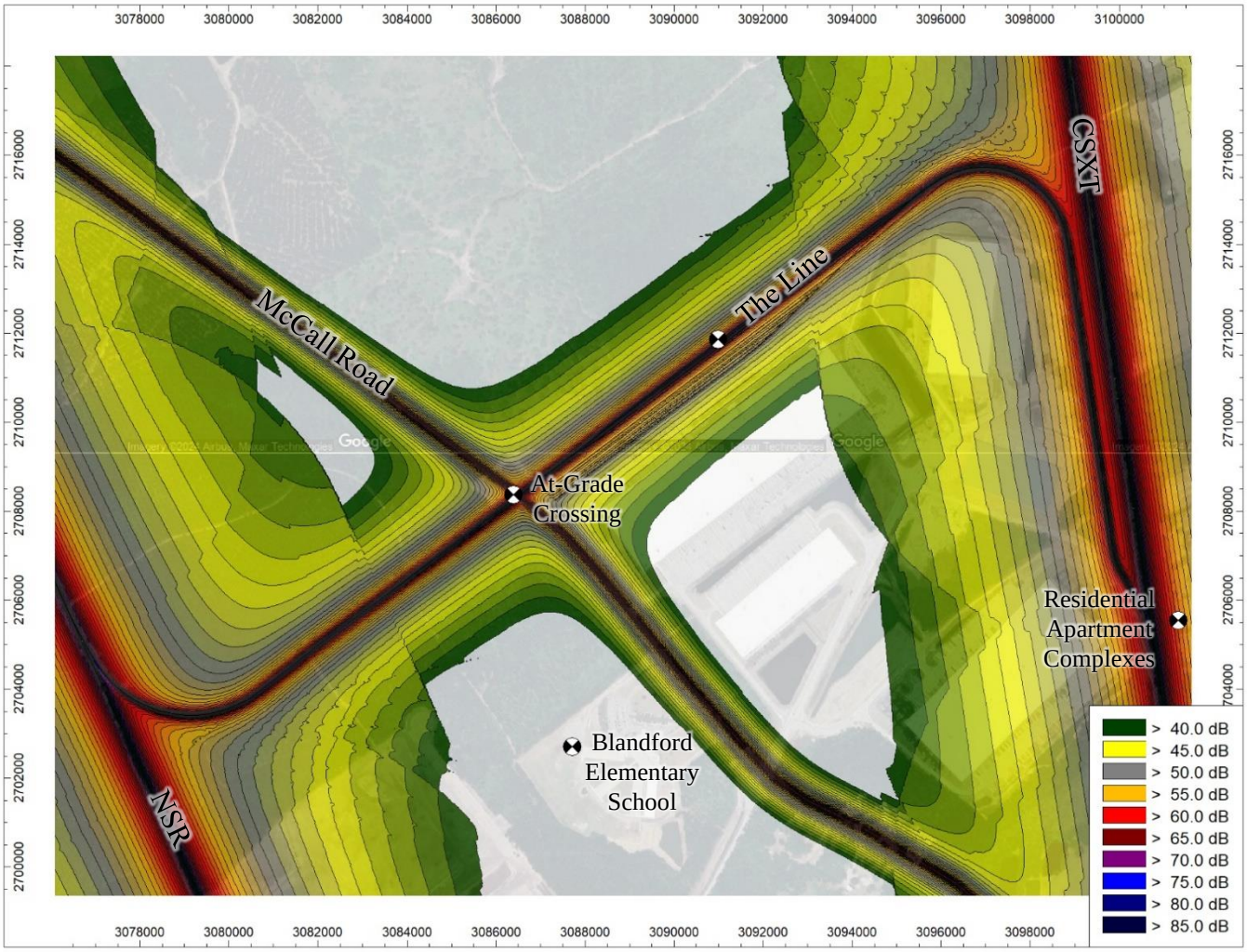
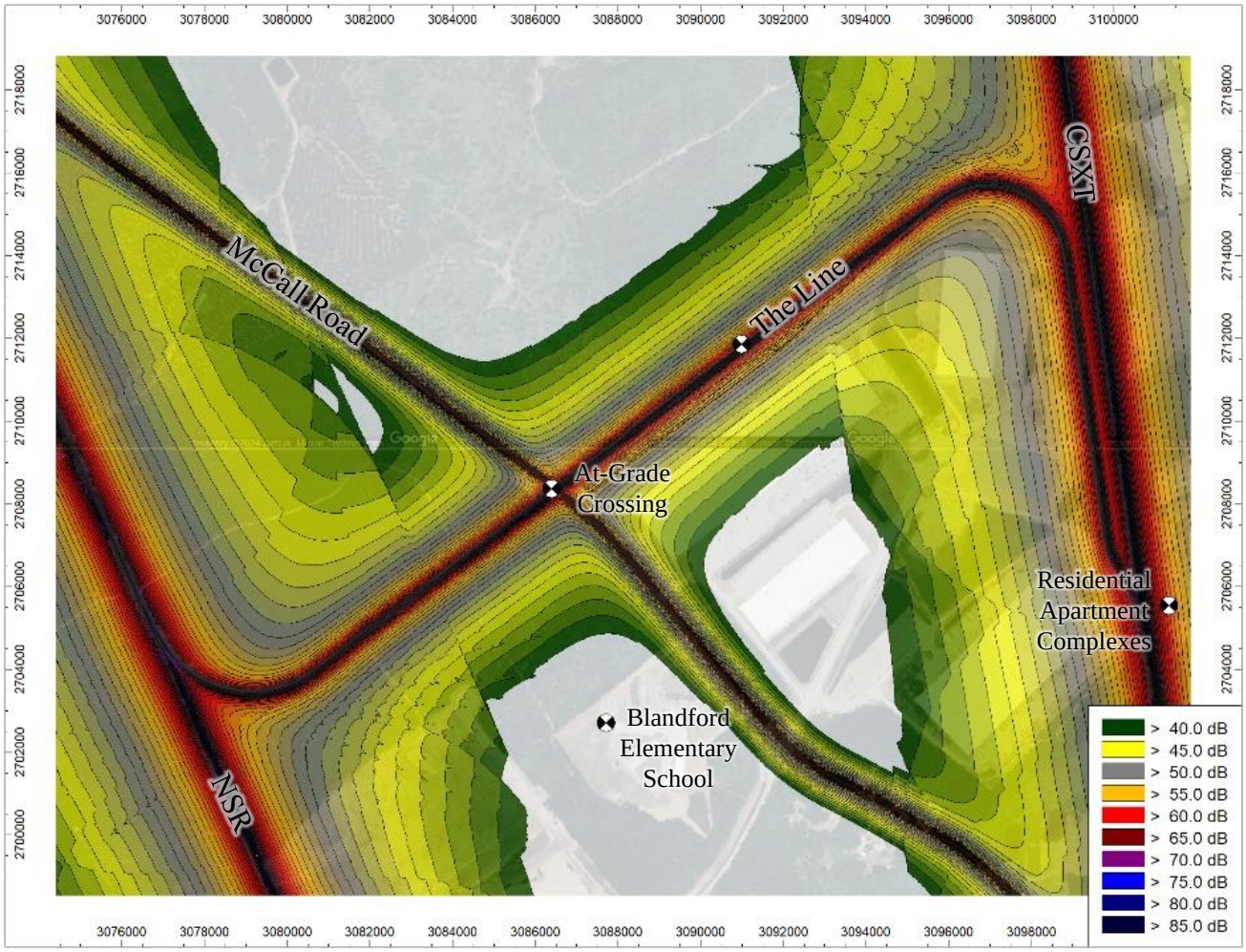


Figure 3-5 shows the results of the Proposed Action noise level modeling in the study area. The dark red contour lines are at 65 DNL (the criteria set by 49 C.F.R. § 1105.7(e)(6) for adverse impacts). Because of the low number of additional trains per day and limited rail yard noise, the 65 DNL contour is contained within the SGIH and does not include any sensitive receptors. Projected noise levels from the Line exceed 65 DNL at approximately 132 feet from the centerline of the Line when unaffected by other noise sources, only 4 feet further than under existing conditions.

Comparing the data from **Figure 3-4** to **Figure 3-5** shows that the 65 DNL noise contour from the Proposed Action is contained within the SGIH property and therefore would imperceptibly increase existing noise levels at the closest sensitive receptors (Effingham Parc Apartments and Town Park Commons) located to the east of the SIT and CSXT lines. Noise levels near the Effingham Parc Apartments and Town Park Commons would only increase by approximately 0.3 DNL at the closest location to the project footprint. Effects to Blandford Elementary School,

located 1,400-feet south of the project footprint, would be negligible as a result of the Proposed Action.

Figure 3-5 Proposed Action Contour Levels in the Study Area



Because the Proposed Action 65 DNL contours do not touch noise sensitive receptors (residences), and increases in existing noise levels are negligible, OEA does not anticipate adverse noise effects as a result of the Proposed Action.

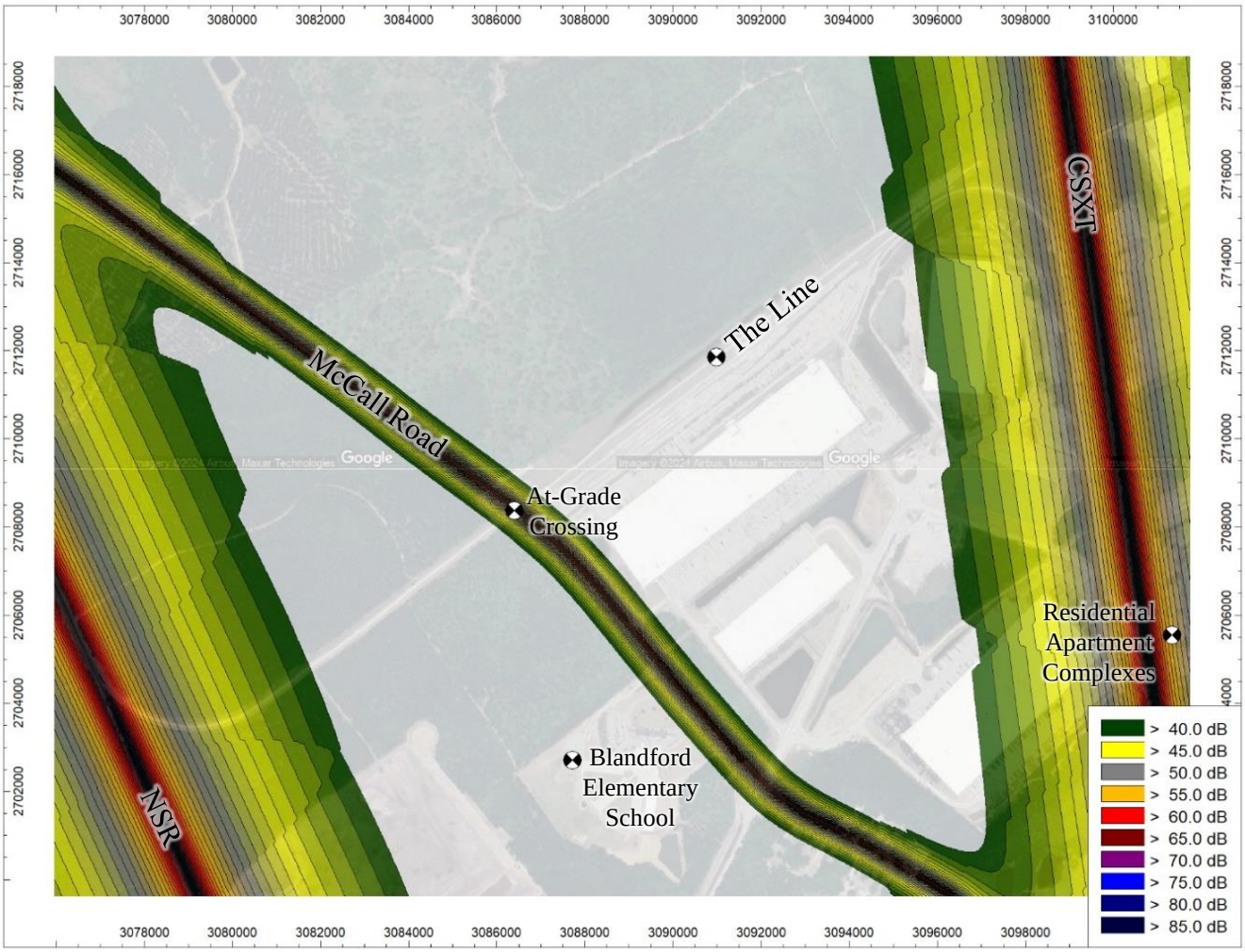
Vibration

OEA also examined the potential for vibration impacts under the Proposed Action. Train operation vibration levels, due to wheel/rail interaction, increase as a function of train speed. FTA guidance for assessing annoyance due to infrequent trains per day is 80 vibration decibels (VdB). Assuming that trains would travel 10 miles per hour, the 80 VdB vibration contour line would be 13 feet from the centerline of the Line. Sensitive receptors within the study area are much farther away than this distance, and therefore increased annoyance due to vibration from train passbys is not expected.

No-Action Alternative

Under the No-Action Alternative, rail service would cease, and no trains would operate on the Line. This would remove rail-related sources of noise from the Line, which would result in decreased noise levels in the study area as compared to existing conditions. However, noise sources from the NSR and CSXT rail lines and McCall Road would remain unchanged. **Figure 3-6** shows the results of the No-Action noise level modeling near the study area.

Figure 3-6 No-Action Contour Levels around the Study Area



3.5.4 Conclusion

OEA concludes that based on modeling changes to noise and vibration levels from projected train operations on the Line, the Proposed Action would result in negligible impacts to noise and vibration. Under the No-Action Alternative, a decrease in noise and vibration would occur due to trains no longer operating on the Line.

3.6 Biological Resources

This section describes the impacts on biological resources that could have resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. The study area, data sources, and approach used to analyze potential impacts are described below. The biological resources considered in this section include vegetation/plant communities, wildlife, and special status species. Special status species include species that are listed or proposed to be listed as threatened or endangered under the ESA; candidate species for ESA listing; sensitive species as listed by the state of Georgia; and migratory birds, including bald and golden eagles.

3.6.1 Approach

OEA defined the study area for biological resources as the project footprint, which includes the total area of disturbance (temporary and permanent) from construction of the Line (see **Section 2.2.1**). To determine the biological resources known to exist or expected to occur in the study area, OEA evaluated vegetation, wildlife habitat, threatened and endangered species, and natural areas. The evaluations included desktop reviews of aerial imagery and publicly available natural resource databases and maps, including USFWS Threatened and Endangered Species Active Critical Habitat Report GIS files, the USFWS Information for Planning and Consultation (IPaC) database, and Georgia Department of Natural Resources (DNR) databases. OEA also reviewed prior environmental studies by Effingham County and SIL that were completed to obtain federal and county permits for the SGIH and construction of the Line.[27] In addition, OEA consulted with USFWS and Georgia state agencies.

3.6.2 Affected Environment

3.6.2.1 Vegetation/Plant Communities

Because construction of the Line has already occurred, OEA does not know the exact composition or area of the vegetation and plant communities in the study area prior to construction. However, prior to the development of the SGIH and construction of the Line, several habitat assessments were conducted from August to October 2011.[28] Four vegetative communities were documented within the SGIH during those studies:

1. Planted pine uplands,
2. Mixed pine/hardwood uplands,
3. Mixed pine/hardwood wetlands,
4. Maintained right-of-way.

Planted pine uplands range in age from early successional to mature merchantable timber. This community is located adjacent to the Line in the study area. These upland communities are dominated by loblolly pine (*Pinus taeda*), slash pine (*Pinus elliottii*), long leaf pine (*Pinus*

[27] These environmental studies include Habitat Assessment for Threatened and Endangered Species, Effingham Industrial Development Authority/Research Forest Tract, Effingham County, Georgia; USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

[28] These habitat assessments include Habitat Assessment for Threatened and Endangered Species, Effingham Industrial Development Authority/Research Forest Tract, Effingham County, Georgia.

palustris), wax myrtle (*Myrica cerifera*), gallberry (*Ilex glabra*), privet (*Ligustrum vulgare*), dog fennel (*Eupatorium capillafolium*), broom-sedge (*Andropogon virinicus*), and bracken fern (*Pteridium aquilinum*), with a minor component of saw palmetto (*Serenoa repens*).

Mixed pine/hardwood uplands are mostly located along the eastern section of the study area, adjacent to the CSXT line. These communities consist of loblolly pine, slash pine, longleaf pine, white oak (*Quercus alba*), sweetgum (*Liquidambar styraciflua*), wax myrtle, gallberry, and bracken fern.

Mixed pine/hardwood wetlands are also located along the eastern section of the study area, adjacent to the CSXT line. These communities are in slightly lower elevations and in locations with poorly drained soils. Species within these communities include loblolly pine, red maple (*Acer rubrum*), swamp bay (*Persea palustris*), black tupelo (*Nyssa sylvatica*), wax myrtle, black willow (*Salix nigra*), possumhaw viburnum (*Viburnum nudum*), and soft rush (*Juncus effusus*).

Maintained right-of-way is characterized by grassed and early successional areas adjacent to the CSXT and NSR rail lines and McCall Road prior to construction. Construction of the Line resulted in a conversion from the above listed habitats to maintained right-of-way adjacent to the Line in the study area.

The SGIH was historically used for pine production on short harvest rotations and research associated with pine production. Prior to development of the SGIH, the property consisted of approximately 2,274 acres of forested upland habitat and 359 acres of forested wetland habitat in various age classes ranging from approximately 10 to 30 years old. The SGIH drains via Dasher Creek to the north, centrally from Willowpeg Creek, and via Sweigoffer Creek in the southern portion. All three tributaries flow northeast to the Savannah River via Mill Creek to Abercorn Creek.

Prior to January 2019, approximately 18.5 acres of the approximate 41-acre study area was cleared as part of the development of 161 acres of the SGIH in Area 1.[29] After construction of the Line, the study area consisted, and continues to consist, of mostly maintained right-of-way. Small areas of planted pine uplands, mixed pine/hardwood uplands, and mixed pine/hardwood wetlands remain along the edges of the study area.

3.6.2.2 Wildlife

Available wildlife habitat is limited to the four vegetative communities discussed above. After construction of the Line, common wildlife species that likely inhabited and are still likely to inhabit the study area include white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), bobcat (*Felis rufus*), gray fox (*Urocyon cinereoargenteus*), Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), armadillo (*Dasypus novemcinctus*), eastern grey squirrel (*Sciurus carolinensis*), eastern rat snake (*Pantherophis alleghaniensis*), and a wide range of birds and insects.[30]

[29] Google Earth imagery dated January 25, 2019.

[30] Georgia Coastal Ecosystems Long Term Ecological Research Network, https://gce-lter.marsci.uga.edu/public/app/species_list.asp; USFWS Savannah National Wildlife Refuge, Species, https://www.fws.gov/refuge/savannah/species

3.6.2.3 Special Status Species

ESA-Listed Species

Section 7(a)(2) of the ESA requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. According to USFWS, critical habitat is defined as "the specific areas within a geographic area, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection."

As previously noted in **Section 3.6.2.1**, prior to the development of the SGIH and construction of the Line, several habitat assessments were conducted within the SGIH from August to October 2011.[31] The assessments did not find any evidence of federally protected species within the study area. SIL was required to obtain a Nationwide Permit (NWP) from USACE for the permanent and temporary fill of jurisdictional wetlands (see **Section 3.7.3.1**) associated with construction of the Line; therefore, USACE consulted with USFWS regarding impacts to species listed under the ESA.[32] **Table 3-6** provides the species list generated by USACE as part of the NWP. See **Appendix E** for more detailed information on each species.

Table 3-6 IPaC Species List Generated by USACE Prior to Construction of the Line

Scientific Name	Common Name	Type	ESA Protection Status
Dryobates borealis	Red-cockaded woodpecker	Bird	T
Ambystoma cingulatum	Frosted flatwoods salamander	Amphibian	T
Drymarchon couperi	Eastern indigo snake	Reptile	T
Lindera melissifolia	Pondberry	Flowering Plant	E

E = Endangered, T = Threatened

To identify any federally listed threatened and endangered species potentially present in the study area, OEA obtained an Official Species List from the USFWS IPaC database on August 27, 2024, and an updated list on March 11, 2025 (see in **Appendix A**).

According to the Official Species List, four threatened, endangered, or proposed threatened or endangered species may be present in the study area (see **Table 3-7**). No designated critical habitat is present in the study area. See **Appendix E** for more detailed information on these species.

[31] Habitat Assessment for Threatened and Endangered Species, Effingham Industrial Development Authority/Research Forest Tract, Effingham County, Georgia.

[32] SIL obtained their NWP via Savannah Industrial Development, LLC, another holding of OmniTRAX; USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

Table 3-7 Current IPaC Species List Generated by OEA on March 11, 2025

Scientific Name	Common Name	Group	ESA Protection Status
Perimyotis subflavus	Tricolored bat	Mammal	PE
Drymarchon couperi	Eastern indigo snake	Reptile	T
Danaus plexippus	Monarch butterfly	Insect	PT
Lindera melissifolia	Pondberry	Flowering Plant	E

E = Endangered, T = Threatened, PE = Proposed Endangered, PT = Proposed Threatened

State Protected Species

For species listed by the State of Georgia as rare, unusual, or threatened and endangered under the Endangered Wildlife Act, the state's jurisdiction is limited to the capture, killing, or selling of protected species, and protection of suitable habitat of protected species on public land. Georgia DNR is charged with administering the rules and regulations of the Endangered Wildlife Act.

During preliminary consultation regarding the Proposed Action, DNR stated that there were no known occurrences of state protected species or species of concern in the Study Area (see **Appendix A**). To determine which State-listed threatened and endangered species could potentially be present in the study area, OEA obtained a list of state protected species known to occur within or near the SGIH from the DNR Georgia Biodiversity Portal database on August 27, 2024 (see **Appendix E**). According to the DNR database, four threatened, rare, or unusual species are known to occur or have historically occurred in or near the SGIH (see **Table 3-8**). Several of the species listed as potentially occurring in or near the SGIH are not anticipated to occur within the study area due to habitat requirements and distribution. The only species known to occupy habitats similar to those habitats found in the study area is the gopher tortoise.

Table 3-8 List of State Threatened, Rare or Unusual Species in the Vicinity of the SGIH[33]

Scientific Name	Common Name	Group	GA Protection Status	Habitat Summary
Elanoides forticatus	Swallow-tailed kite	Bird	R	River swamps; marshes, open pine and bottomland forest with super canopy pines.
Heterodon simus	Southern hognose snake	Reptile	R	Sandhills; fallow fields; longleaf pine-turkey oak
Sarracenia minor var. *minor*	Hooded pitcherplant	Flowering Plant	U	Wet savannas, pitcherplant bogs

[33] Rare Georgia State Protected by Quarter Quad (https://georgiabiodiversity.org/portal/element_unit_map/qq/ga_protected). Quarter quads: Rincon, GA-SC, SW; Springfield, GA, SE; Meldrim, GA, NE.

Scientific Name	Common Name	Group	GA Protection Status	Habitat Summary
Gopherus polyphemus	Gopher tortoise	Reptile	T	Sandhills; dry hammocks; longleaf pine-turkey oak woods; old fields

T = Threatened, R = Rare, U = Unusual (and thus deserving of special consideration).

Gopher tortoise – as discussed above in **Section 3.6.2.3**, the study area may have contained suitable habitat for the gopher tortoise prior to construction of the Line. The gopher tortoise typically occurs in well-drained, sandy soils in relatively open grassy areas with a sparse pine overstory. Gopher tortoises dig burrows in dry places such as sandhills, flatwoods, prairies and coastal dunes or in human-made environments such as pastures, grassy roadsides and old fields. For the gopher tortoise to thrive, the animal generally needs three things: well-drained sandy soil (for digging burrows), plenty of low plant growth (for food), and open, sunny areas (for nesting and basking). According to the field survey results of studies conducted by Effingham County in 2011, only a very small portion of the study area may have contained suitable habitat for the species, and no gopher tortoise burrows were observed during field surveys.[34] No suitable habitat for the gopher tortoise is currently present in the study area.

3.6.2.4 Migratory Birds and Eagles

The MBTA and the BGEPA are administered by USFWS to protect native birds. Any activity, intentional or unintentional, resulting in take (including killing, capturing, selling, trading, and transport) of migratory birds, including eagles, is prohibited unless otherwise permitted by the USFWS (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. Actions must be taken to avoid or minimize impacts to migratory birds and to prevent or abate the detrimental alteration of the environment for the benefit of migratory birds, as practicable.

Based on the results of studies completed by Effingham County in 2011, and a review of recent aerial imagery, there is no suitable habitat for bald or golden eagles, and no eagles were observed in the study area.[35] However, the MTBA extends protections to more than 1,000 species of birds in the United States. .Migratory bird species documented in the USFWS IPaC[36] species list with the highest probability of presence in the study area based on species habitat requirements include brown-headed nuthatch (*Sitta pusilla*), chimney swift (*Chaetura pelagica*), Chuck-will's-widow (A*ntrostomus carolinensis*), Eastern whip-poor-will (A*ntrostomus vociferus*), painted bunting (*Passerina ciris*), prairie warbler (*Setophaga discolor*), prothonotary warbler (*Protonotaria citrea*), red-headed woodpecker (*Melanerpes erythrocephalus*). See **Appendix E, Table 1** for more detailed information on these species. The study area does not contain any documented breeding or nesting grounds of significance for migratory birds, but suitable habitat

[34] Habitat Assessment for Threatened and Endangered Species, Effingham Industrial Development Authority/Research Forest Tract, Effingham County, Georgia.

[35] Id.; Google Earth imagery dated January 25, 2019.

[36] USFWS IPaC Report, Project Code: 2024-0096725. March 11, 2025.

for migratory birds was present prior to construction of the Line and remains present in the study area.

3.6.3 Environmental Consequences

3.6.3.1 Vegetation/Plant Communities

Construction

Construction of the Line required the removal of vegetation and plant communities and resulted in permanent loss of planted pine uplands, mixed pine/hardwood uplands, and mixed pine/hardwood wetlands communities in the project footprint. As noted above, these communities were converted to maintained right-of-way. But impacts to vegetation and plant communities did not result in significant changes to the landscape or ecological values of the adjacent vegetative communities. Further, impacts were localized to the vicinity of the Line and were minor in the context of the surrounding landscape.

Operations

Rail operations would not alter or have any effects on the existing vegetative communities present in the study area beyond what was altered or effected during construction of the Line. Maintenance activities would include vegetation clearing, trimming, and/or treatment with herbicide in the right-of-way of the Line. These activities would be infrequent and brief, localized to the vicinity of the Line, and would have no impacts to the vegetative communities in the study area.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to vegetation and plant communities beyond impacts resulting from the prior construction of the Line. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be no potential impacts to vegetation and plant communities from maintenance activities under the No-Action alternative.

3.6.3.2 Wildlife

Construction

Construction of the Line required the removal of vegetation and resulted in a permanent loss of forested habitat for wildlife in the study area. The species that may have inhabited the study area prior to construction are mobile, would have been able to relocate to suitable habitat nearby, and are highly adaptable to habitat disturbance. Although forested habitat was lost, the total area lost was negligible in the context of the home ranges of wildlife expected in the project footprint. Furthermore, the maintained right-of-way and stormwater pond associated with the Line would have provided suitable feeding and foraging habitat for species discussed above. Therefore, OEA determined that any impacts to wildlife resulting from construction of the Line were likely negligible.

Operations

The Proposed Action could result in wildlife mortality or injury from operation-related collisions or crushing. Collisions or crushing would be more likely to affect smaller, less mobile species (such as insects and reptiles) that are not able to move away quickly from moving equipment, trains, and other vehicles. Collisions with larger animals and birds would be less likely because those animals could move more quickly and vacate the rail right-of-way. OEA expects that wildlife fatalities and injuries from maintenance vehicles and trains would be infrequent because trains operating on the Line typically move at slow speeds (maximum speed is 10 mph), which would allow most species to avoid collision or crushing. During rail operations, OEA expects that wildlife fatalities and injuries from trains could occur but would be infrequent and would result in negligible impacts to wildlife populations. Therefore, OEA anticipates that there would be negligible impacts to wildlife associated with rail operations.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to wildlife beyond impacts resulting from the prior construction of the Line. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be a decrease in potential impacts on wildlife from operation-related collisions or crushing or maintenance activities under the No-Action Alternative.

3.6.3.3 Special Status Species

ESA-Listed Species

The most recent IPaC species list did not identify red-cockaded woodpecker and frosted flatwood salamander as species that may be present in the project area. Therefore, OEA is only analyzing potential impacts to these species from construction under the Proposed Action. Moreover, the tricolored bat and monarch butterfly were not proposed to be listed under the ESA until after construction of the Line was completed. Therefore, OEA is only analyzing impacts to these species from rail operations under the Proposed Action and the No-Action Alternative.

During preliminary consultation, USFWS notified OEA that there were no anticipated impacts to ESA protected species in the study area (see **Appendices A and E**).

Construction

Because SIL was required to obtain a NWP from USACE for the permanent and temporary fill of jurisdictional wetlands associated with construction of the Line, USACE consulted with USFWS regarding impacts to species listed under the ESA. [37] As the Line has already been constructed, OEA is using USACE's previous effect determinations for its analysis of the impacts that could have resulted from construction of the Line.

Red-cockaded woodpecker – Based on aerial imagery at the time and information in the habitat assessment, the mature pine forest in the study area did not have an open understory, with few or

[37] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

no midstory or canopy hardwood trees.[38] Per the Effects Determination Guidance for Endangered & Threatened Species (EDGES), USACE determined that construction of the Line may have affected but was not likely to adversely affect the red cockaded woodpecker.[39]

Frosted flatwood salamander – USACE determined that construction of the Line would not impact long-leaf pine-flatwoods or slash pine flatwoods. Therefore, per EDGES, USACE determined that construction of the Line would not have affected the frosted flatwood salamander.[40]

Eastern indigo snake – Prior to construction of the Line, USACE concluded that the site contained moderately suitable soils for the gopher tortoise.[41] According to surveys conducted in the area, no gopher tortoises or gopher tortoise burrows were observed in the SGIH, but it is possible the eastern indigo snake could have still used wetlands in the study area during summer months.[42] There were no confirmed sightings of the eastern indigo snake within or in the vicinity of the SGIH prior to construction.[43] Per EDGES, USACE determined that construction of the Line may have affected but was not likely to adversely affect the eastern indigo snake. [44]

Pondberry – Prior to construction, USACE determined that construction of the Line would not affect pondberry.[45]

Based on the information available at the time, USACE determined that construction of the Line may have affected but was not likely to adversely affect the red-cockaded woodpecker and the eastern indigo snake. USACE also determined that construction of the Line would have no effect on the frosted flatwoods salamander and pondberry due to the lack of suitable habitat. No species-specific mitigation was included in the NWP permit.

[38] Id.

[39] USACE' Savannah District and the USFWS' Georgia Ecological Service office jointly developed EDGES to improve coordination on projects that may affect species listed under the ESA.

[40] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

[41] As discussed above in **Section 3.6.2.3 Special Status Species**, eastern indigo snake in Georgia is closely associated with the gopher tortoise, a reptile that excavates extensive underground burrows, which provide the snake shelter from winter cold and protection from dehydration in the summer heat.

[42] Habitat Assessment for Threatened and Endangered Species, Effingham Industrial Development Authority/Research Forest Tract, Effingham County, Georgia.

[43] Id.; Rare Georgia State Protected by Quarter Quad (https://georgiabiodiversity.org/portal/element_unit_map/qq/ga_protected). Quarter quads: Rincon, GA-SC, SW; Springfield, GA, SE; Meldrim, GA, NE.

[44] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

[45] Id.

Operations

Potential impacts could occur during rail operations to ESA-listed species or species proposed to be ESA-listed. Maintenance activities would include vegetation maintenance in the right-of-way such as vegetation clearing, trimming, or treatment with herbicide.

Eastern indigo snake and *pondberry* – operations would have no effect on the eastern indigo snake and pondberry due to the lack of suitable habitat in the study area.

Tricolored bat – rail operations would not impact the ability of the tricolored bat to feed, forage, or breed in the study area because rail operations occur during the day when bats are roosting. Maintenance activities would include vegetation clearing, trimming, or treatment with herbicide in the right-of-way, but these activities would not be expected to impact tricolored bats because no roosting trees would be removed. OEA determined that rail operations would have no effect on tricolored bat based on the USFWS IPaC Determination Key for the species (see **Appendix E**). Thus, OEA concludes that rail operations would not impact the continued existence of the species.

Monarch butterfly – the study area contains potentially suitable habitat for the monarch butterfly in the right-of-way. Rail operations and maintenance vehicles are not expected to impact the monarch butterfly because trains do not exceed 10 mph. Maintenance vehicles also typically travel at slow speeds on the access road because it is an unpaved road that is not part of the public road network. Maintenance activities could include vegetation clearing, trimming, and/or treatment with herbicide in the right-of-way. While some flowering plants could be removed through these activities, impacts would be negligible due to the limited area that would be treated with herbicide. Therefore, OEA concludes that continued rail operations would not impact the continued existence of the species.

No-Action Alternative

Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, no further impacts to ESA listed species or species proposed for ESA-listing would occur beyond impacts resulting from the prior construction of the Line.

State Protected Species

Construction

Construction of the Line may have affected state protected species. Suitable habitat for gopher tortoise may have been present prior to construction. As noted in **Section 3.6.2.3**, only a small portion of the study area contained suitable habitat for gopher tortoise. However, no burrows were found during the field surveys conducted by Effingham County. Therefore, construction of the Line likely had no effect on gopher tortoise.

Operations

Rail operations would have no effect on gopher tortoise, due to the current lack of suitable habitat in the study area. As noted in **Section 3.2.6.3**, DNR notified OEA that there were no known occurrences of state protected species or species of concern in the study area during

preliminary consultation. Therefore, OEA determined that rail operations would have no effect on these species.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to State protected species beyond what has already occurred during construction of the Line. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease.

3.6.3.4 Migratory Birds and Eagles

Construction

Construction of the Line resulted in removal of vegetation that likely provided habitat for migratory birds in the study area. As noted in **Section 3.6.2.4**, the study area did not contain any known nesting or breeding areas of significance for migratory bird species prior to construction of the Line. Migratory bird species that were expected to occur in the study area prior to construction (see Appendix E, **Table 1**) were mobile, and it is reasonable to assume they would have been able to relocate to nearby suitable habitat during construction of the Line. Although forested habitat was lost, the total area lost was negligible in the context of the home ranges of wildlife expected in the project footprint. Furthermore, the maintained right-of-way and stormwater pond associated with the Line would have provided suitable habitat for the migratory bird species previously discussed in **Section 3.6.2.4**. Therefore, impacts to migratory birds associated with construction of the Line were determined to be negligible.

Construction of the Line had no effect on bald and golden eagles because no suitable habitat was present in the study area prior to construction.

Operations

Operation of trains and maintenance vehicles are expected to have negligible effects on migratory birds. Minimal clearing or alteration to vegetation providing habitat for migratory birds would occur as part of rail operations. Migratory birds expected to occur in the study area are mobile and able to relocate to suitable habitat nearby. Therefore, the Proposed Action would have a negligible effect on migratory birds.

Operations would have no effect on bald and golden eagles because there is no suitable habitat for the species present in the study area.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to migratory birds beyond what has already been described in the construction section above. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be no potential impacts on migratory birds from maintenance activities associated with rail operations under the no-action alternative.

3.6.4 Conclusion

Based on the analysis above, OEA concludes that the Proposed Action would result in minor impacts to biological resources due to the permanent loss of vegetation communities and the 'may affect, not likely to adversely affect' determination for special status species.

Construction of the Line required the removal and permanent loss of vegetation and plant communities in the project footprint but impacts to vegetation and plant communities did not result in significant changes to the landscape or ecological values of the adjacent vegetative communities. Rail operations would not result in impacts beyond what was required for construction of the Line. Therefore, OEA has determined the Proposed Action would have minor impacts to vegetation.

Construction of the Line may have temporarily displaced common wildlife and migratory bird species in the project footprint. The species that may have inhabited the area prior to construction are mobile, would have been able to relocate to suitable habitat nearby, and are highly adaptable to habitat disturbance. Although forested habitat was lost, the maintained right-of-way and stormwater pond associated with the Line would have provided suitable feeding and foraging habitat for species discussed above. During rail operations, OEA expects that wildlife fatalities and injuries from trains could occur but would be infrequent and would result in negligible impacts to wildlife populations. Therefore, OEA determined that the Proposed Action would have negligible impacts to wildlife and migratory birds.

Construction of the Line may have had an impact on special status species. Based on the information available at the time, USACE determined that construction of the Line may have affected but was not likely to adversely affect the red-cockaded woodpecker and the eastern indigo snake. Operations of the Line were determined to have no effect on special status species due to lack of suitable habitat. Due to the 'may affect, not likely to adversely affect' determination for the red-cockaded woodpecker and eastern indigo snake, OEA has determined the Proposed Action would have had minor impacts to special status species.

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to biological resources beyond what has already been described in the construction sections above. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be a decrease in potential impacts to biological resources from maintenance activities and potential collisions associated with rail operations under the No-Action Alternative.

3.7 Water Resources

This section describes the impacts on water resources that resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. The study area, data sources, and approach used to analyze potential impacts to water resources are described below. Water resources considered in this section include groundwater, surface waters (streams), wetlands, floodplains, water quality, and coastal zone management.

3.7.1 Approach

OEA defined the study area for surface waters, wetlands, and floodplains as the project footprint which includes the total area of disturbance (temporary and permanent) from construction of the

Line (see **Section 2.2.1**). The study area for groundwater is defined as the three aquifers beneath the Coastal Georgia region (surficial aquifer, Brunswick aquifer, and the Floridan aquifer). The study area for coastal zone management is defined as Effingham County.

3.7.2 Affected Environment

3.7.2.1 Surface Waters (Streams) and Wetlands

USACE and state environmental departments administer Section 404 and 401 of the Clean Water Act (CWA), 33 U.S.C. §§ 1251-1389, which regulates the discharges of fill into waters of the United States (WOTUS), including wetlands. Wetlands are defined at 33 C.F.R. § 328.3(c)(1) as "those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils." OEA used wetland delineations provided by SIL and SIT, previously approved USACE permits, USFWS National Wetlands Inventory (NWI), and the U.S. Geological Survey (USGS) National Hydrography Dataset to identify and characterize waterways and hydrology within the study area. The study area includes three wetland areas, which are classified as freshwater forested wetlands.

3.7.2.2 Floodplains

Floodplains are defined as any land area susceptible to being inundated by waters from any source (44 C.F.R. § 59.1) and are often associated with surface waters and wetlands. Floodplains are valued for their contribution to natural flood and erosion control, biological productivity, and ecological benefits and functions. Floodplains can also be considered a hazard area because buildings, structures, and properties located in floodplains can be inundated and damaged during floods.

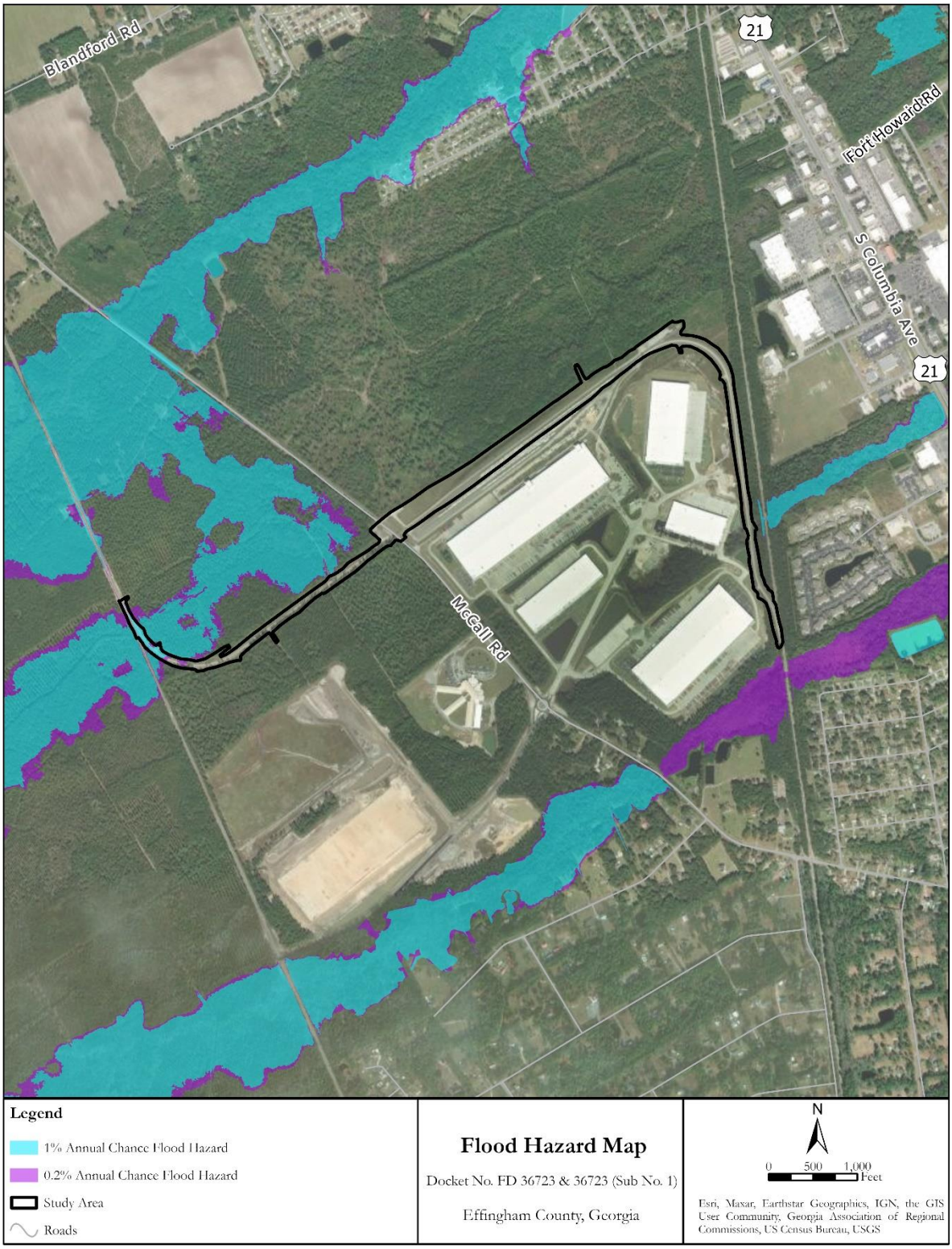
According to the Federal Emergency Management Agency (FEMA) National Flood Hazard Layer, one 100-year floodplain (1% annual chance of base flood) was identified in the study area (see **Figure 3-7**) near the connection to the NSR line. There is also a 100-year floodplain located near the connection to the CSXT line; however, this floodplain is located outside the study area.

3.7.2.3 Groundwater

The three aquifers beneath the Coastal Georgia region are the surficial aquifer, Brunswick aquifer, and the Floridan aquifer. The thickness of the surficial aquifer is typically less than 50 feet and consists mostly of beds of unconsolidated sand and shell. The Brunswick aquifer is located between the surficial and Floridan aquifers. The thickness of this aquifer ranges from 200 feet to less than 100 feet. Within the Coastal Georgia region, the Brunswick aquifer is commonly used as an alternate water source to the Floridan aquifer. Nearly all groundwater supplied in the region is from the Floridan aquifer system. The Floridan aquifer is primarily comprised of limestone, dolostone, and calcareous sand.[46]

[46] USGS – Groundwater Conditions of Georgia, https://ga.water.usgs.gov/infodata/gwconditions/#:~:text=Groundwater%20Conditions%20of%20Georgia

Figure 3-7 FEMA Flood Hazards



3.7.2.4 Coastal Zone Management

The Georgia DNR Coastal Resources Division administers the Georgia Coastal Management Program (GCMP), as outlined in the federal Coastal Zone Management Act (CZMA) of 1972.[47] The GCMP addresses the economic development concerns and natural resources in eleven coastal counties in Georgia, including Effingham County. Within these counties, all waters including the coastal ocean and all submerged lands are considered part of the coastal area.

3.7.3 Environmental Consequences

As discussed below, construction of the Line resulted in impacts to surface waters and wetlands and floodplains. Operation of the Line could result in additional impacts to water resources including surface waters and wetlands, floodplains, and water quality.

3.7.3.1 Surface Waters (Streams) and Wetlands

Construction

Construction of the Line resulted in permanent and temporary fill of wetlands. According to USACE (Permit File No. SAS-2003-20390), construction of the Line impacted a total of 0.66 acres of jurisdictional wetlands as shown in **Table 3-10** below. Impacts associated with construction of the Line were addressed through two separate NWP authorizations from USACE. The first NWP (January 2020 Permit)[48] authorized a total of 2.5 acres of permanent impacts to wetlands to construct an access road (Gateway Parkway) and railroad crossing associated with development of the SGIH. Of those 2.5 acres of authorized impacts, only 0.49 acres of permanent fill (Wetland Impact Area I) in wetlands were associated with construction of the

Line. The second NWP (July 2020 Permit)[49] authorized a total of 0.17 acres of impacts to wetlands for the connection between the CSXT line and the SGIH. The stabilization of a culvert outfall located in the CSXT right-of-way required placement of rip rap (rock), which resulted in 0.02 acres of permanent fill in wetlands and 0.03 acres of temporary fill in wetlands to provide access for the work area (Wetland Impact Area L). Construction of the Line between the CSXT right-of-way and the SGIH, the maintenance access road, and a ballast walkway resulted in 0.07 acres of permanent fill and 0.05 acres of temporary fill in wetlands (Wetland Impact Area M).

Table 3-9 Wetlands Impacted from Construction of the Line

Wetland Impact Area	Permanent Impact (Acres)	Temporary Impact (Acres)
I	0.49	0.0
L*	0.02	0.03
M*	0.07	0.05

[47] Georgia Department of Natural Resources – Coastal Resources Division, Georgia Coastal Management Program, https://coastalgadnr.org/CoastalManagement.

[48] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Nationwide 14 Approval Letter, January 2, 2020.

[49] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

*Located within the CSXT right-of-way.

Because the loss of jurisdictional wetlands associated with the two NWP authorizations was greater than 0.10 acres, USACE required compensatory mitigation to offset the unavoidable impacts to wetlands. Purchase of compensatory mitigation credits from an approved mitigation bank was required before any permitted work was allowed to begin. Savannah Industrial Development, LLC (SID)[50] purchased compensatory mitigation credits for both NWP authorizations from the AA Shaw Wetland Mitigation Bank. Verification of the credits' purchase is documented in the AA Shaw Wetland Mitigation Bank credit ledger, which is available for public view online as part of the Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS).[51]

In accordance with the Georgia Erosion and Sedimentation Control Act of 1975, as amended, SIL was required to use best management practices (BMPs) (e.g. silt fencing, etc.) during construction of the Line to avoid and minimize siltation and runoff, and to protect the water quality of downstream wetland areas.[52]

Operations

Potential impacts to surface waters and wetlands could occur during rail operations because of maintenance activities and incidental pollutant discharges. Maintenance activities would include vegetation maintenance in the right-of-way and repairs and maintenance associated with the track, the access road, ditches, culverts, and other associated rail infrastructure. Vegetation would be periodically cleared or trimmed, or use of herbicides in the right-of-way may be required to ensure safe rail operations. Clearing or trimming could temporarily alter wetland vegetation and structure. Any changes in wetland structure could alter the habitat, water quality, and hydrology functions that the wetland provides. Maintenance activities could disturb the ground surface, resulting in mobilized sediment. Any mobilized sediment or improper use of herbicides could reach wetlands and could degrade vegetation communities, wildlife habitat, water quality, and overall wetland productivity.

SIT would be required by the Georgia Erosion and Sediment Control Act of 1975, as amended, to properly maintain existing stormwater infrastructure and use of stormwater BMPs to convey, filter, and dissipate runoff. SIT would also be required by the Georgia Pesticide Control Act of 1976, as amended, to use a licensed pesticide applicator to apply herbicides or other chemicals for vegetation management. Because SIT would have to comply with these regulatory requirements, OEA expects that any impacts to surface waters and wetlands from operations and maintenance activities would be infrequent, brief, localized, and minimal. Therefore, OEA is not recommending any additional mitigation.

[50] SID is a holding of OmniTRAX.

[51] RIBITS, AA Shaw Mitigation Bank Credit Ledger Summary https://ribits.ops.usace.army.mil/ords/f?p=107:43::ledger::43:P43_BANK_ID:1971

[52] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to surface waters and wetlands beyond what has already been described in the construction subsection above. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be no impacts on wetlands from maintenance activities and incidental pollution discharges under the No-Action Alternative.

3.7.3.2 Floodplains

Construction

The connection to the NSR line was constructed in a FEMA mapped 100-year floodplain associated with Dasher Creek. Before construction could occur, SIL was required to consult with the Effingham County Floodplain Administrator to confirm that construction would not result in the water surface elevation (WSE) of the base flood to increase more than one foot at any point on property outside the SGIH. Construction of the rail line embankment resulted in changes to the floodplain width. Accordingly, multiple culverts and drainage ditches were constructed along the Line to mitigate impacts to floodplains. This resulted in WSE rises of less than 1-foot, which were contained to the SGIH. Therefore, in consultation with the Effingham County Floodplain Administrator, it was determined that given the limited and contained floodplain impacts, no Conditional Letter of Map Revision (CLOMR) from FEMA was required.[53]

The Line's connection to the CSXT line was constructed immediately upstream of a designated FEMA 100-year floodplain. The 100-year floodplain is located just outside of the study area. Based on consultation with the Effingham County Floodplain Administrator, it was determined that Effingham County recognizes this area upstream of the mapped floodplain as an "unofficial floodplain." Therefore, impacts to this area were included in the floodplain analysis. While the constructed crossing structure for the CSXT connection resulted in a rise in WSE in the "unofficial floodplain," all rises were less than 1-foot; the impacts were contained to the same property; and the floodplain only extended a maximum of 105 feet. Given that this was located outside of the FEMA Zone AE without Floodway, submittal to FEMA was not required.[54]

The Line was designed and constructed to maintain existing water patterns and flow conditions and provide long-term hydrologic stability by conforming to natural gradients. Impacts to floodplains during construction were mitigated by installing culverts, pipes, and drainage ditches, and by avoiding WSE rise to property outside of the SGIH. As explained above, impacts to floodplains were authorized by the Effingham County Floodplain Administrator.[55]

Operations

Rail operations and maintenance would not result in any changes to WSE within the floodplain beyond what has already been described in the construction subsection above. However, to ensure all project-related culverts are clear of debris to avoid flow blockages, flow alteration, and

[53] HDR, SID LLC/SGIH Shortline: Hydraulics Review Technical Memorandum, January 17, 2020.

[54] HDR, SID LLC/SGIH Shortline: Hydraulics Review Technical Memorandum, January 17, 2020.

[55] HDR, SID LLC/SGIH Shortline: Hydraulics Review Technical Memorandum, January 17, 2020.

increased flooding, OEA is recommending mitigation requiring SIT to inspect all project-related culverts semi-annually (or more frequently, as seasonal flows dictate) for debris accumulation and shall remove and properly dispose of debris promptly (**WAT-MM-1**). If the recommended mitigation measure is implemented, no additional impacts to floodplains are anticipated from operation of the rail line and associated rail yard.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to floodplains beyond what has already been described in the construction subsection above. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease.

3.7.3.3 Water Quality

Construction

Construction of the Line required a conditional Water Quality Certification[56] under Section 401 of the CWA, which was obtained with the NWP authorized by USACE (see in **Section 3.7.3.1**). Permit authorizations from Effingham County for clearing and grading activities were also required in accordance with the provisions of the Erosion and Sedimentation Act of 1975, as amended, the Rules of the Georgia DNR, Environmental Protection Division (EPD), Chapter 391-3-7, and the Code of Effingham County, Chapter 30 – Article III.[57]

During construction, SIL was required to use BMPs (e.g., silt fencing, etc.) during construction to avoid and minimize siltation and runoff, and to protect the water quality of downstream surface waters and wetland areas.[58] In accordance with the Erosion and Sedimentation Act of 1975, as amended, and the Rules of the Georgia DNR, EPD, Chapter 391-3-7, the Line was designed to meet the standards of the Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), and the Effingham County Stormwater Management Local Design Manual (LDM). Further, the SGIH was designed to incorporate Better Site Planning Techniques, Better Site Design Techniques, and Low Impact Development to avoid and minimize water quality impacts.[59] Because SIL was required to comply with these requirements when constructing the Line, OEA has determined that construction of the Line likely had no impacts on water quality.

Operations

[56] USACE Savannah District, 2017 Nationwide Permit Regional Conditions https://www.sas.usace.army.mil/Portals/61/docs/regulatory/2017%20Regional%20Conditions.pdf?ver=2017-03-20-153050-080.

[57] Effingham County Development Services, Clearing and Grading Permit Numbers: LDA-meSGIH3_NS; LDA-meSGIH3; LDA-RFT_SGIH_ph 3; LDA-WFJT17-R_(2)

[58] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

[59] Development of Regional Impact Findings Report prepared by the Coastal Regional Commission (CRC) of Georgia for Effingham County dated July 5, 2012.

Potential impacts to water quality could occur from maintenance activities and incidental pollutant discharges during rail operations. Maintenance activities would include vegetation maintenance in the right-of-way and repairs and maintenance associated with tracks, the access road, ditches, culverts, and other associated rail infrastructure. These activities could disturb the ground surface, resulting in mobilized sediment, and require the use of chemicals (such as herbicides). Any mobilized sediment or the improper use of herbicides could also impact water quality.

Proper maintenance of existing stormwater infrastructure would prevent downstream water quality degradation and help prevent downstream flooding and erosion. Use of stormwater BMPs as required by the Georgia Erosion and Sediment Control Act of 1975, as amended and the Rules of the Georgia DNR, EPD, Chapter 391-3-7, would convey, filter, and dissipate stormwater runoff to minimize impacts to downstream water quality. Because these regulatory requirements enforce strict standards for erosion control, sedimentation prevention, and proper chemical usage, OEA expects that any impacts to water quality from rail operations would be negligible and is not recommending any further mitigation.

No-Action Alternative

Because construction of the Line has already occurred, the No-Action Alternative would not result in any further impacts to water quality. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be no potential impacts on water quality under the No-Action Alternative.

3.7.3.4 Coastal Zone Management

Construction

The NWP authorizations from USACE included a general CZMA consistency concurrence issued by Georgia DNR. No coastal zone resources (i.e. ocean and adjacent shorelands) exist within or near the project footprint. Therefore, construction of the Line had no adverse impacts to coastal zone management or coastal zone resources.

Operations

Rail operations would not be expected to have impacts on coastal zone management objectives or coastal zone resources because there are no coastal zone resources near the project footprint where operations would take place. Based on the CZMA consistency concurrence associated with the NWP authorizations from USACE, construction of the Line had no impacts to coastal zone resources.

No-Action Alternative

Because construction of the Line already occurred, the No-Action Alternative would not result in any impacts to coastal zone resources. Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, there would be no potential impacts on coastal resources under the No-Action Alternative.

3.7.4 Conclusion

Based on the analysis described above, OEA concludes that the Proposed Action would result in minimal or negligible impacts to surface waters and wetlands, floodplains, groundwater, and water quality.

Construction of the Line resulted in impacts to surface waters and wetlands, which were authorized by USACE and were mitigated with the purchase of compensatory mitigation credits from an approved mitigation bank. Any potential impacts from rail operations would be minimized through maintenance of all existing stormwater conveyance and detention structures, as well as through regulatory requirements, specifically the use of appropriate BMPs where ground disturbing activities are required in accordance with the Erosion and Sedimentation Act of 1975, as amended, and the Rules of the Georgia DNR, EPD, Chapter 391-3-7, and the use of a licensed pesticide applicator when applying herbicides or other chemicals for vegetation management as required by the Georgia Pesticide Control Act of 1976, as amended.

Water quality impacts from construction of the Line were minimized by using appropriate BMPs and construction of required stormwater conveyance and detention structures.[60] Because SIT would be required to comply with the Erosion and Sedimentation Act of 1975, as amended, the Rules of the Georgia DNR, EPD, Chapter 391-3-7, and the Georgia Pesticide Control Act of 1976, as amended, OEA expects any impacts to water quality from rail operations and maintenance activities would be infrequent, brief, localized, and negligible.

Construction of the Line resulted in impacts to floodplains, which were documented and authorized by the Effingham County Floodplain Administrator. Impacts to floodplains during construction were mitigated by the installation of culverts, pipes, and drainage ditches, and avoided WSE rise to property outside of the SGIH. Further, the Line was designed and constructed to maintain existing water patterns and flow conditions and to provide long-term hydrologic stability by conforming to natural gradients. To ensure all project-related culverts are clear of debris to avoid flow blockages, flow alteration, and increased flooding, OEA is recommending mitigation requiring SIT to inspect all project-related culverts semi-annually (or more frequently, as seasonal flows dictate) for debris accumulation and shall remove and properly dispose of debris promptly (**WAT-MM-1**).

3.8 Hazardous Materials and Waste Sites

This section describes the impacts of hazardous materials and waste sites that could have resulted from construction of the Line and the potential impacts that could result from the continued operation of the Line. The study area, data sources, and the approach used to estimate impacts from construction and analyze potential impacts of the Proposed Action and No-Action Alternative are described below.

[60] USACE Savannah District Regulatory Division, Permit File Number SAS-2003-20390 Memorandum for Record: Department of the Army Memorandum Documenting General Permit Verification, July 15, 2020.

3.8.1 Approach

OEA defined the study area as the area within a 500-foot buffer from the centerline of the Line. OEA then conducted a search for hazardous material release sites in the study area. For purposes of this analysis, a hazardous material release site is an area that has been affected by a documented release of hazardous material into soil, groundwater, surface water, sediments, and/or air. Hazardous materials are hazardous substances as defined by the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. § 103), including hazardous wastes. EPA defines hazardous waste as waste with properties that make it dangerous or potentially harmful to human health or the environment.

To search for documented releases of hazardous materials, OEA obtained an Environmental Data Resource (EDR)[61] to identify known hazardous materials within the study area. An EDR report was generated for the study area on September 11, 2024. EDR searched agency databases in a search radius that meets or exceeds the American Society for Testing and Materials (ASTM) Standard E1527-13 minimum search distance.[62] OEA conducted a review of the EDR database reports to determine if there are any existing or potential properties of concern relative to soil and/or groundwater contamination or properties that could potentially contain hazardous waste in the study area.

3.8.2 Affected Environment

While SIT would have a common obligation to carry hazardous materials upon reasonable request, SIT does not carry hazardous materials under current operations. Additionally, the EDR report did not identify any hazardous materials sites within the study area. However, two sites were identified approximately 0.5 miles northeast of the study area as shown in **Figure 3-8**. Both sites were issued No Further Action Letters (NFA) in 2020 and 2017. A brief description of the two sites is presented below:

- Gate Petroleum #225 (390 South Columbia Avenue, Rincon, GA): Reported to the Leaking Underground Storage Tank database on 02/08/1991. The site received a No Further Action (NFA) with an active remediation system installed at the site on 03/02/2020.
- Enmark #450 (403 South Columbia Avenue, Rincon GA): Reported to the Leaking Underground Storage Tank database on 01/27.2017. The site received an NFA letter on 03/09/2017.

In addition to the EDR report, the online Georgia EPD databases were reviewed to determine if any former or current sites or potential hazardous sites of concern were listed. No additional hazardous sites were found.

[61] EDR is a third-party database report used in the environmental due diligence process that searches relevant state and federal environmental databases.

[62] The exact distance can vary depending on the specific list being searched but is often considered to be a one-mile radius for federal and state hazardous waste site lists and a quarter-mile for other lists.

Figure 3-8 Hazardous Material Site Locations



3.8.3 Environmental Consequences

The Proposed Action and No-Action Alternative would likely not be impacted by sites currently listed as hazardous material or hazardous waste sites. Two sites were identified outside the study area and are not anticipated to affect the Proposed Action and No-Action Alternative due to cleanup status and the issuance of an NFA.

Construction

Construction of the Line had no impact on documented hazardous waste sites. Two hazardous waste sites were identified outside the area of disturbance, and construction of the Line would not have disturbed soils that could have been previously contaminated.

Operations

Under the Proposed Action, no impacts from rail operations to hazardous waste sites are expected. SIT does not have oil or fuel tanks greater than 1,320 gallons and will continue to use similar tanks under the Proposed Action. Therefore, SIT is not subject to the Spill Prevention, Control, and Countermeasure (SPCC) regulations (40 CFR 112)[63] and does not currently have a SPCC plan.[64] Additionally, trains do not currently carry hazardous materials and are not anticipated to carry hazardous materials under the Proposed Action.[65] However, if a reasonable request to carry hazardous materials is made, SIT shall conduct any such shipments in compliance with the requirements established by the U.S. Department of Transportation, the U.S. Department of Homeland Security, the U.S. Transportation Security Administration, FRA, and the Pipeline and Hazardous Materials Safety Administration.

No-Action Alternative

Under the No-Action Alternative, the Board would not authorize the Proposed Action, and rail operations would cease. Accordingly, no impacts to hazardous materials or hazardous waste sites are expected as a result of the No-Action Alternative.

3.8.4 Conclusion

Under the Proposed Action, trains would not have oil or fuel tanks greater than 1,320 gallons and are not anticipated to carry hazardous materials unless requested to do so. Under the No-Action Alternative, train operations would cease. Because of these reasons, OEA concludes that the Proposed Action and No-Action Alternative would result in no impacts from hazardous materials or hazardous waste sites.

[63] A SPCC plan is a document that outlines how a facility will respond to an oil spill. The EPA requires facilities to have an SPCC plan if they meet certain oil storage capacity thresholds.

[64] Docket No. FD 36723, Savannah Industrial Logistics, LLC (SIL) - Construction Exemption & Docket; No. FD 36723 (Sub-No. 1), Savannah Industrial Transportation LLC (SIT)-Lease and Operation Exemption - Line of Savannah Industrial Logistics, LLC in Effingham County, Ga.; Information Request No.1, August 2024

[65] Id.

3.9 Cultural Resources

This section describes the impacts on cultural resources that could have resulted from construction of the Line and the potential impacts that could result from the Proposed Action and No-Action Alternative. The study area, data sources, and the approach used to estimate impacts from construction and analyze potential impacts of the Proposed Action and No-Action Alternative are described below.

3.9.1 Approach

The Board's decision whether to approve the Proposed Action is a federal action under NEPA and a federal undertaking under Section 106 of the NHPA (54 U.S.C. § 306108). Section 106 regulations at 36 C.F.R. Part 800 require federal agencies to consider the effects of their undertakings on historic properties that are listed in, or eligible for listing in, the NRHP. Historic properties can include buildings, precontact and historic archaeological sites, districts, objects, and structures, as well as traditional cultural properties and landscapes. The term "historic property" also includes properties of religious or cultural significance to Indian Tribes. For the Proposed Action, OEA is coordinating the environmental review process under NEPA with the Section 106 process, and the NEPA term "cultural resources" as used in this section is interchangeable with the Section 106 term "historic properties."

In addition to the NHPA, OEA must also comply with other federal laws that relate to historic properties:

- The Archaeological and Historic Preservation Act of 1974, 16 U.S.C. §§ 4–9 – 469c-2, provides for the survey, recovery, and preservation of significant scientific, prehistoric, archaeological, or paleontological data when such data may be destroyed or irreparably lost because of a federal, federally licensed, or federally funded (in part or whole) project.

- American Indian Religious Freedom Act of 1978, 42 U.S.C. § 1996, which provides for the protection and preservation of American Indian sites, possessions, and ceremonial and traditional rites.

OEA increases the efficiency of its environmental review process by concurrently reviewing cultural resources under NEPA and Section 106. To be determined eligible for inclusion in the NRHP, a cultural resource must be important in American history, architecture, archaeology, engineering, or culture; must possess integrity of location, design, settings, materials, workmanship, feeling, or association; and must meet at least one of the following four criteria (36 C.F.R. Part 800):

A. It is associated with events that have made a significant contribution to the broad patterns of our history.

B. It is associated with the lives of persons significant in our past.

C. It embodies the distinctive characteristics of a type, period, or method of construction, or that represents the work of a master, or that possesses high artistic values, or that

represents a significant distinguishable entity whose components may lack individual distinction.

D. It has yielded, or may be likely to yield, information important in prehistory or history.

Properties may be of local, state, or national importance. Typically, historic properties are at least 50 years old, but younger properties may be considered for listing if they are of exceptional importance (Criteria Consideration G). Further, a property must be evaluated by its association with an important historic context and retain integrity of those features necessary to convey its significance (National Park Service 1991).

In this Draft EA, OEA defined the cultural resources study area as the Area of Potential Effects (APE). Pursuant to 36 C.F.R. §§ 800.4(a)(1) and 800.16(d), (y), the APE is the geographic area(s) within which the undertaking may directly or indirectly affect cultural resources. Within the APE, impacts on cultural resources are evaluated for both historic structures (above-ground cultural resources) and archaeology (below-ground cultural resources). To evaluate the potential for the Proposed Action and No-Action Alternative to affect cultural resources, OEA defined the APE as the project footprint within which ground disturbance activities occurred during construction.

In a letter dated May 6, 2024, OEA initiated Section 106 consultation with the Georgia SHPO, THPOs, and Tribal governments with a possible interest in the Proposed Action. OEA consulted and coordinated with the Alabama-Quassarte Tribal Town, Catawba Indian Tribe of South Carolina, Coushatta Tribe of Louisiana, Muscogee (Creek) Nation, and Seminole Tribe of Florida (see **Appendix A**). No responses have been received from any Tribes to date.

3.9.2 Affected Environment

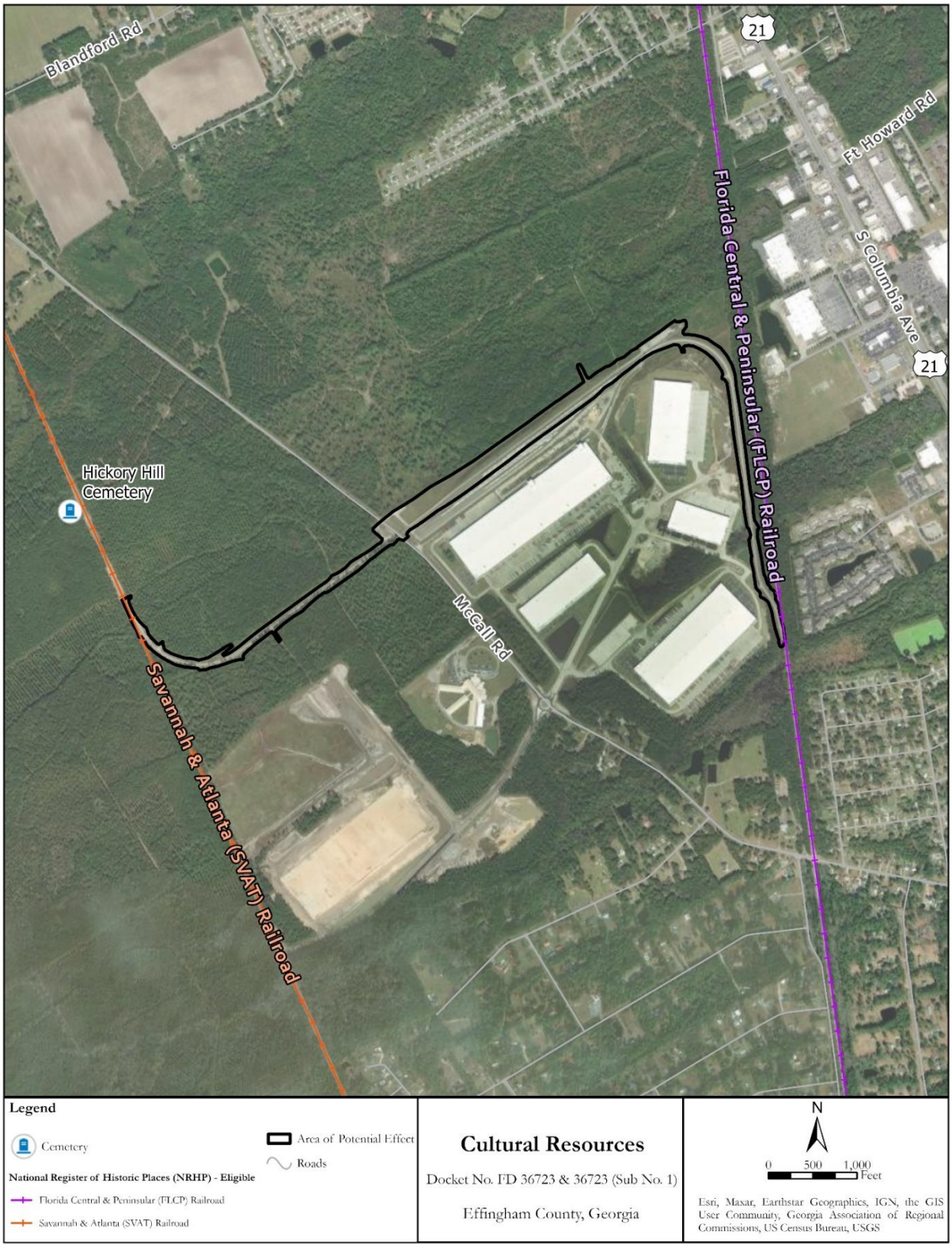
OEA conducted background research on the study area, including a review of Georgia's Natural, Archaeological, and Historic Resources Geographic Information System (GNAHRGIS), to examine information on previous cultural resource surveys, archaeological sites, historic buildings, structures, landscapes, and districts within the APE.

Research using GNAHRGIS revealed that there are two previously recorded NRHP-eligible historic properties located in the APE. These include the Savannah & Atlanta Railroad (SVAT, now under CSXT ownership) to the west, and the Florida Central & Peninsular Railroad (FLCP, now under NSR ownership) to the east (see **Figure 3-9**).

There have been a number of previous cultural resource studies in this location associated with other planned development activities. In 2004, R.S. Webb & Associates performed a Phase I cultural resources survey for 2,189 acres (885.9 hectares) of the approximate 3,239-acre (1,310.8 hectares) SGIH, previously referred to as the "Rincon Research Tract" (Gantt et al. 2004).[66] The remaining 1,050 acres (424.9 hectares) of the tract was designated as wetlands. The Phase I cultural resources survey included a literature review and an intensive field survey within the

[66] International Paper Realty Corporation. Phase I Cultural Resource Survey, Rincon Research Tract Draft Report, June 4, 2004

Figure 3-9 Cultural Resources



Proposed Action's APE. This survey did not identify any historic properties. The current APE is located within this large, previously surveyed, tract of land.

Between 2019 and 2022, the area was again surveyed and evaluated as part of USACE permitting efforts associated with the Line and the SGIH. As part of those permitting efforts, two historic properties were identified, both located within the current APE. These included the SVAT line at the eastern end of the APE, and the FLCP line at the western end of the APE. Both railroads were previously determined to be eligible for listing on the NRHP in 2019 as documented in the SHPO's *Georgia's Railroads, 1833-2015: Historic Context and Statewide Survey*.

3.9.3 Proposed Action Environmental Consequences

Construction

As discussed above, two historic properties are located within the APE of the previously constructed Line – the SVAT line and the FLCP line. In a letter dated June 4, 2024, the SHPO stated that due to the scope and location of the work, existing modern intrusions, and existing ground disturbance, the Proposed Action would have no adverse effect to the two historic properties, as defined in 36 C.F.R. Part 800.5(d)(1) (see **Appendix A**). After reviewing all the previous studies and documentation associated with the Proposed Action and considering the input from the SHPO, OEA has determined that construction of the Proposed Action had no adverse effect on cultural resources.

Operations

The continued operation of the Line under the Proposed Action would have no adverse impacts to the two historic properties within the APE because the Line is currently operating and the increase in projected traffic would not affect the two historic properties. After reviewing all the previous studies and documentation associated with the Proposed Action and considering the no adverse effect determination by the SHPO, OEA has determined that continued operation of the Line would have no adverse impact on cultural resources.

No-Action Alternative

Under the No-Action Alternative, all rail service would cease, and no trains would operate on the Line. OEA has determined that the No-Action Alternative would have no adverse impact on the two historic properties within the APE because the rail line would remain in place, and there would be no changes to the two historic properties.

3.9.4 Conclusion

OEA has determined that the Proposed Action would have no adverse impact to historic properties due to the scope and location of the work, existing modern intrusions, and existing ground disturbance. Similarly, the No-Action Alternative would also have no adverse impact to historic properties because the existing rail line would remain in place, rail operations would cease, and there would be no changes to the two historic properties.

3.10 Additional Impacts

This section describes other past, present, and reasonably foreseeable future projects and actions that might have impacts that could combine with the impacts of the Proposed Action. Because the Proposed Action would not involve any new rail construction, as construction of the Line was completed in 2020, this analysis focuses on the incremental impacts of rail operations when added to impacts of other past, present, and reasonably foreseeable future projects and actions. The sections that follow describe the approach, affected environment, and environmental consequences for this analysis.

3.10.1 Approach

OEA defined the study area and analysis period for other impacts to include reasonably foreseeable projects and actions that could affect the same resource areas as the Proposed Action. For this analysis, OEA considered the reasonably foreseeable projects and actions discussed below.

3.10.2 Past, Present, and Reasonably Foreseeable Future Projects and Actions

Based on a review of publicly available data and resources from GDOT, SIL and SIT, and Balfour Beatty (a construction company), OEA identified the following reasonably foreseeable independent projects and actions.

Savannah Gateway Industrial Hub, The SGIH is a 2,600-acre multimodal logistics park with active development underway. As part of the Georgia Ready for Accelerated Development (GRAD) Program, the SGIH offers sites of various sizes and configurations that are fast-tracked for construction. Development is divided into four areas. [67] Area 1 is between the CSXT line and McCall Road. Land south of the Line in this area has been developed, and current tenants of SGIH are located here, including the current shipper. Area 2 is between McCall Road and the NSR line. Area 3 is between the NSR line and Effingham Parkway (which is currently under construction). Area 4 is between Effingham Parkway and Hodgeville Road. See **Figure 2.1** for a map of the areas.

Effingham Parkway, GDOT Project Id: 0006700. This proposed project consists of constructing a two-lane roadway that begins at State Route 30 and ends at Blue Jay Road. The typical section of roadway is proposed to have 12-foot lanes with 10-foot outside shoulders (including 6.5-foot paved) on an 80-foot right-of-way. Total length of the project is approximately 6.4 miles. Approximately 1.5 miles of the parkway transects the SGIH (see **Figure 2.1**). Construction of Effingham Parkway began in September 2021 and is scheduled for completion in April 2025 (Balfour Beatty, 2025).

3.10.3 Other Impacts by Resource

As discussed in **Section 3.1** through **Section 3.9** of this Draft EA, the impacts of the Proposed Action range from no impacts to minimal impacts.. OEA reviewed the resource areas assessed in this Draft EA to determine if there would be reasonably foreseeable impacts from construction of

[67] Savannah Gateway Industrial Hub, Multimodal Logistic Park Near Port of Savannah (available at: https://savannahgatewayindustrialhub.com/wp-content/uploads/2025/03/Savannah-Gateway-Industrial-Hub-_March-2025-1.pdf.)

the SGIH and the Effingham Parkway that could combine with the operational impacts associated with the Proposed Action.

For resources in which there would be no impact from the Proposed Action, there would be no beneficial or adverse impacts to combine with or add to. These resource areas include:

- Air Quality
- Hazardous Materials and Waste Sites
- Land Use, Zoning, and Local Plans
- Cultural Resources

The following examines the potential impacts of the Proposed Action when added to the impacts of the independent projects listed above.

3.10.3.1 Transportation Delay and Safety

OEA anticipates that delays from the Proposed Action at the McCall Road at-grade crossing would be minimal and would not cause the LOS to decrease below LOS A. Additional construction of the SGIH could result in an increase in vehicle, truck, and rail transportation. However, construction of Effingham Parkway would provide an alternate north-south route for trucks and vehicles to avoid McCall Road. Additionally, the Proposed Action has the potential to provide an alternative to truck transportation, further reducing truck traffic on McCall Road associated with the industrial park. Therefore, OEA does not anticipate that the Proposed Action would result in additional impacts when combined with the impacts of the SGIH and Effingham Parkway.

3.10.3.2 Energy

The continued operation of the Line would require diesel for the trains. The consumption of diesel would likely increase compared to current rail operations due to the anticipated increase in train traffic as the SGIH develops.

Regarding vehicles, there will likely be benefits as well as impacts related to the development and construction of the SGIH and the construction of Effingham Parkway. A potential benefit may include additional routes for vehicles into and out of the SGIH property, thereby reducing the number of vehicles idling at the existing at-grade crossing at McCall Road. Alternatively, based on the anticipated development, traffic may increase as the development and construction of the SGIH continues because trucks may need to deliver more goods between potential additional shippers and the Line, resulting in an increase of vehicle usage and fuel consumption.

Due to the energy efficiency of increased rail usage to and from the SGIH property, coupled with a more extensive transportation network, OEA does not anticipate additional impacts on energy resources.

3.10.3.3 Noise and Vibration

Only projects adjacent to or very close to the rail line footprint could potentially result in additional impacts related to noise and vibration. The 65 DNL noise contours for rail operations extend 132 feet from the centerline of the Line under the Proposed Action. Noise sources further

away may cause small noise increases, which typically would not be noticeable. Vibration is even more localized; therefore, additional vibration impacts would be unlikely.

Planned SGIH construction is located north and west of the Proposed Action, and Effingham Parkway is located west of the Proposed Action. All areas are greater than 132 feet from the centerline of the Line. Thus, because OEA does not expect any noise impacts from the other reasonably foreseeable projects, there would be no additional noise impacts.

3.10.3.4 Biological Resources

Under the Proposed Action, trains would continue to operate at 10 mph. Collisions or crushing that may result from operations would be more likely to affect smaller, less mobile species, but would be expected to have negligible effects to species populations. Development and construction of the SGIH, as well as the construction of Effingham Parkway, have the potential to impact biological resources due to vegetation removal, which could result in decreased and fragmented wildlife habitat. However, because the Proposed Action would not include the removal of any vegetation, OEA does not expect the Proposed Action and the other reasonably foreseeable projects to create any additional impacts to biological resources.

3.10.3.5 Water Resources

OEA did not analyze potential impacts on groundwater, Coastal Zone Management, and floodplains, because, as described in **Section 3.7**, OEA expects that rail operations would not impact groundwater, coastal zone management objectives, or coastal zone resources. OEA determined that, the recommended mitigation (**WAT-MM-1**) is imposed, operation of the Line would also not impact floodplains.

OEA determined that, because SIT would be required to comply with the Georgia Erosion and Sediment Act of 1975, as amended; the Rules of the Georgia DNR, EPD, Chapter 391-3-7; and the Georgia Pesticide Control Act of 1976, as amended, operation of the Line would result in infrequent, brief, localized and minimal impacts to surface waters (streams) and wetlands and water quality. The SGIH and Effingham Parkway could contribute to impacts on surface waters (streams) and wetlands and water quality. Based on a review of the previous wetland delineations and proposed site plans, the SGIH construction would likely result in surface waters and wetland impacts. However, both the SGIH and Effingham Parkway would require a Nationwide 404 permit under the CWA from USACE for minimal impacts to wetlands (less than 0.5 acres) if filling of wetlands cannot be avoided during construction. Therefore, OEA does not anticipate impacts from the Proposed Action to result in additional impacts to water resources when combined with the impacts from SGIH and Effingham Parkway.

3.10.4 Conclusion

As explained above, OEA does not anticipate that the Proposed Action would result in additional impacts when combined with the impacts of the development and construction of the SGIH and the construction of Effingham Parkway.

Chapter 4
Mitigation

This chapter describes mitigation measures that, if imposed by the Board, would avoid, minimize, or mitigate potential environmental impacts of the Proposed Action. In this Draft EA, OEA is preliminarily recommending one mitigation measure based on the results of OEA's environmental analysis. If the Board decides to grant SIL and SIT's request for after-the-fact authority to construct and operate the Line, the mitigation measure set out in this chapter could become a condition of the Board's decision. Because the Line has already been constructed, OEA is preliminarily recommending mitigation resulting from impacts associated with rail operations under the Proposed Action.

4.1 Conditioning Power of the Board

The Board has the authority to impose conditions to mitigate environmental impacts, but that authority is not limitless. Any mitigation measure the Board imposes must relate directly to the transaction before the Board, must be reasonable, and must be supported by the record before the Board. OEA's consistent practice has been to recommend mitigation only for those impacts that would result directly from a Proposed Action. The Board does not require mitigation for pre-existing environmental conditions.

Sometimes applicants propose voluntary mitigation to address potential environmental impacts of their proposals. Voluntary mitigation could replace, supplement, or extend further than mitigation measures the Board might otherwise impose. The Board's practice is to require compliance with any voluntary mitigation agreed to by applicants in any final decision authorizing a Proposed Action. SIL and SIT have not submitted any voluntary mitigation to date. However, as explained in the Draft EA, SIT's compliance with regulatory requirements applicable to operating the Line would minimize potential environmental impacts.

4.2 Preliminary Nature of the Mitigation Process

OEA's preliminary recommended mitigation measures are based on information available to date, consultation with appropriate agencies, and the environmental analysis presented in this Draft EA. OEA emphasizes that the recommended mitigation measure is preliminary and invites the public and agencies to comment on the proposed mitigation. For OEA to assess the comments effectively, it is critical that the comments be specific regarding any desired mitigation and the reasons why the suggested mitigation would be appropriate.

After OEA issues the Draft EA for public comment and the public comment period closes, OEA will prepare a Final EA. The Final EA will respond to all substantive comments, include additional analyses if appropriate, and make final recommendations to the Board on what mitigation to impose. After the conclusion of the EA process, the Board will make its final decision considering both the transportation merits of the proceeding and the full environmental record — which includes this Draft EA, the Final EA, all public and agency comments received, and OEA's final recommended mitigation.

4.3 OEA's Preliminary Recommended Mitigation

The following section provides OEA's preliminary recommended mitigation measure. OEA recommends that, if the Board grants after-the-fact authority to construct and operate the proposed rail line, such authority should be subject to the mitigation measure identified below. If a resource area is not listed below, OEA did not identify any adverse impacts that warrant mitigation and has therefore not proposed mitigation measures for this resource area.

4.3.1 Water Resources

WAT-MM-1. During rail operations, SIT shall ensure that all culverts and bridges along the previously constructed rail line are clear of debris to avoid flow blockages, flow alteration, and increased flooding. SIT shall inspect all culverts and bridges semi-annually (or more frequently, as seasonal flows dictate) for debris accumulation and shall remove and properly dispose of debris promptly.