





Lower Snake River Dams: Benefit Replacement Report

FINAL: AUGUST 2022

Contents

Top-left photo on cover page courtesy: PG 99-032-028, Kyle Laughlin Photograph Collection, PG 99, Special Collections and Archives, University of Idaho Library, Moscow, Idaho.

Executive Summary

In late 2021 Gov. Jay Inslee and U.S. Sen. Patty Murray of Washington state announced a process to examine whether there are reasonable means for replacing the benefits provided by the four Lower Snake River Dams (LSRD), sufficient that breaching of the dams could be part of a comprehensive salmon recovery strategy for the Pacific Northwest. Findings from this process will be used by Gov. Inslee and Sen. Murray to determine their recommendations on a path forward for the LSRD.

This report describes the range of services and associated benefits currently provided by the dams and the actions that have been considered to replace or improve upon these services and benefits if the dams were to be breached, along with expected results of replacement actions and anticipated costs. This report does not constitute a recommendation on whether the Lower Snake River Dams should be either breached or retained. Following public input on the draft report from June 9, 2022, through July 11, 2022, and direct engagement led by the senator and governor, this final report, along with other information, will be used by the governor and senator in making their recommendations on a path forward for the region.

[Note: this report uses endnotes for references and superscripts for cost estimates adjusted to 2022 dollars throughout the report. The first time a new source is referenced it is given a numerical endnote (e.g., [1, 2, 3,] etc.), and if that same reference is used again throughout the report it uses the same numbered endnote. All references are listed at the end of the report. For every dollar value adjusted to 2022 dollars the report includes a letter superscript (e.g., [A, B, C,] etc.), and information on the index and methodology used for each adjusted dollar value is provided in Appendix C.]

Background

The U.S. Army Corps of Engineers (Army Corps) operates four run-of-river dams and locks on the lower Snake River in Washington including Ice Harbor, which was constructed between 1955 and 1961, Lower Monumental which was constructed between 1961 and 1969, Little Goose which was constructed between 1963 and 1970, and Lower Granite which was constructed between 1965 and 1975. Together, the LSRD produce 900 average megawatts (aMW) of electricity annually and up to 3,033 MW of power at peak capacity, helping to meet peak power loads and contributing to the reliability of the power transmission grid. They also provide more than 100 miles of river navigation and transportation between Lewiston, Idaho, and the Tri-Cities, Washington typically continuing down the Columbia River to lower Columbia ports.

The dams significantly altered the physical, chemical, hydrological, and biological processes in the Snake River, changing it from free flowing to a series of reservoirs. All species of salmon that use the Snake River are currently listed as threatened or endangered under the Endangered Species Act (ESA). The LSRD are among the largest human-constructed obstacles Snake River fish and other aquatic species encounter on their migration to and from the Pacific Ocean. They significantly limit the ability for salmon to spawn in the main river channel and create slack water conditions that favor other species, many of which prey on salmon. The LSRD were designed with fish ladders to facilitate adult fish passage, and dam operators have added juvenile fish passage facilities and provided improvements to adult passage facilities over time. Despite these efforts, salmon abundance continues to decline. While the LSRD certainly are not the only cause of this decline, their impact on salmon outcomes is significant.

Salmon are central to culture and wellbeing in tribal nations throughout the Pacific Northwest, all of which experience adverse impacts from salmon decline. Several tribal nations have been impacted by the presence and operation of the LSRD. These tribes signed treaties with the United States in the mid-1800s. In those treaties, most of the tribes ceded millions of acres of the Columbia Basin to the federal government, but reserved certain rights, including the right to fish at their usual and accustomed fishing places throughout the Columbia Basin. As succinctly stated in *United States v. Winans*, the treaties were "not a grant of rights to the Indians, but a grant of right from them - a reservation of rights not granted."[1] There is a direct connection between the cession of those lands and the ability of the tribes to continue to have fish to take, as the tribes would never have ceded those millions of acres without the right to resort to the traditional fishing locations. The treaties included not only the right to access the traditional fishing locations, however distant from the reservation, but also that there would be fish to catch. The treaty fishing right carries with it an inherent right to protect the resource – the fish – from human caused impacts.[2,3] With the damming of the Snake River, the wealth of the Snake River has been transferred through energy production, transportation, and irrigation to the detriment of salmon and the communities that rely on salmon. The tribes' diminished access to their natural resources undermines their ability to maintain their culture, language, and religious ceremonies. The tribes currently have access to a fraction of a percent of the natural resources once provided by the Snake River at the time of signing the Treaties. The federal government as fiduciary of the tribes has the legal responsibility to "ensure that Indian treaty rights are given full effect."[4]

The dams affect tribal people in two main ways: (1) they reduce the abundance and distribution of salmon and reduce salmon fishing opportunities and harvest available to tribal people and (2) they cut off access to tribal fishing, hunting, and harvesting of roots, plants and berries and prevent tribal people from holding religious and cultural ceremonies at their usual places. On a cultural and spiritual scale, the impact of the loss of salmon has been devastating to tribes. The Affiliated Tribes of Northwest Indians stated that tribes in the Pacific Northwest are "united by salmon; by the Northwest rivers that salmon, steelhead, lamprey, and native fish depend upon; and by the interconnectedness of salmon with their ecosystems – from the orca in the ocean and Puget Sound to the nutrients salmon supply to the furthest inland streams…The fate of our [ATNI] Tribes and Northwest salmon are intertwined."[8]

Replacement of LSRD benefits is possible – at significant cost and with a major infrastructure program

This report describes how, based on a review of existing information and outreach to technical experts, tribes, and stakeholders, the services provided by the LSRD could be replaced, or even improved upon, and where they cannot be replaced or improved, mitigation and compensation could be provided. In describing how services and benefits might be replaced, this report assumes that replacement actions would be in place before dam breaching so there is no loss of benefits. In specific instances where actions cannot be implemented in advance, mitigation measures would be needed during a transition period. Replacing the services provided by the dams could range in cost from $10.3 billion to $31.3 billion (see Table 1), and anticipated costs are still not available for several necessary actions.

Although this report describes a potential path forward to successfully replace, or even improve upon services currently provided by the LSRD, significant work would be needed to bring this outcome about. Congressional authorization would be needed for the Army Corps to pursue breaching the dams. Moving forward with dam breaching also would require establishing timelines and milestones for results, agreement on a comprehensive funding strategy, additional analyses to maximize benefits at all stages of the process, continued technological advancements and implementation of a significant infrastructure program.

Successfully replacing the services provided by the dams would require a process that engages communities to guide actions, monitor progress and adapt to new information as work moves forward. Governance structures will be needed to support consultation and collaboration amongst federal and state agencies, tribes, public and private utilities, agriculture, and many other interests. All of this must be sustained with funding and attention through the years that will be needed to carry out the actions before the dams could be breached.

Benefits for salmon, orca, tribes and fishing communities drive interest in a breaching option

The potential for improvements to West Coast salmon populations is one of the main factors prompting interest in breaching the LSRD. Salmon and steelhead have declined by over 90% compared to their pre-dam abundances in the Columbia and Snake River system and the total abundance of salmon and steelhead in the Columbia River is at or near the level it was when the first Endangered Species Act (ESA) listings were registered in the mid-1990s.[5] A recent draft National Oceanic and Atmospheric Administration (NOAA) report identified hydrosystem-related limiting factors have the greatest impact on survival on four of the Snake River stocks. The NOAA report states achieving healthy, harvestable stocks will require a comprehensive suite of management actions including significant reductions in direct and indirect mortality from mainstem dams and the restoration of the lower Snake River through breaching of the LSRD. It also emphasizes the urgency of action to reverse the downward trend of the populations and create improvements to subsequent generations of salmon necessary to avoid extinction and rebuild the populations.[6]

Over the past two years, returns of some Snake River salmon and steelhead populations have increased compared to extreme low returns of the previous five years, but are still only a fraction of historic levels and far below the goals agreed to by the NOAA Columbia Basin Partnership Task Force, a diverse set of stakeholders and tribes. Currently, 42% of Snake River spring/summer Chinook populations have natural origin spawner abundances at or below the Quasi-Extinction Threshold (QET). For Snake River steelhead, 19% of populations are at or below QET. It is expected that more of these populations will be reduced to below QET levels within a few years without significant action to improve survival. The percentage of returning adult salmon per outmigrating juvenile fish is below the level of sustainability. In addition to increased survival, breaching the LSRD is expected to provide a long-term benefit to species that spawn or rear in the mainstem Snake River habitats, such as fall Chinook, with an estimated 140 miles of additional spawning habitat on the lower Snake River representing a 15-fold increase.[7]

Salmon are critically important to tribes of the Columbia and Snake River Basins and throughout the Pacific Northwest. On the impact of the hydroelectric system on tribal communities, the Affiliated Tribes of Northwest Indians stated, "the modern Northwest with its massive irrigation, hydropower, and storage systems was built on the backs of tribal peoples from the 1930s on, through the use and destruction of the lands, rivers, and fisheries we have lived with for thousands of years and tribal cultures and lifeways are rooted in place and tied to their homelands, but tribes cannot just relocate to access traditional resources."[8] The LSRD reservoirs have inundated tribal cultural sites and affected tribes' ability to carry out cultural rituals and honor ancestors at many places important to them.

Scientific models by the National Oceanographic and Atmospheric Administration (NOAA) and the Comparative Survival Study (a federal-state-tribal fish model) show that breaching the LSRD would significantly improve passage for salmon, steelhead, and lamprey. Breaching the LSRD could increase tribal harvest by 29% annually and would have the highest likelihood of removing salmon from ESA listing and maintaining treaty and trust obligations compared to other alternatives.[9] Breaching the LSRD would permanently drain the four lower Snake River reservoirs and could create substantial benefits for affected tribes. It would allow tribal peoples to renew their close religious and spiritual connection with approximately 34,000 acres of land where their ancestors lived and are buried and allow them to properly care for their grave sites. They could return to more than 700 locations where they were accustomed to live, fish, and hunt, harvest plants, roots and berries, conduct cultural and religious ceremonies, and pursue other aspects of their normal traditional lives.[10, 11]

Columbia River salmon and steelhead support long-standing and valuable recreational, commercial, and subsistence fisheries throughout the Columbia Basin and along the Pacific coast. Within the Columbia Basin, recreational fishing is a major economic driver of rural communities. It has been estimated that restored salmon fisheries in the Columbia Basin could generate up to $1 billion[AP] annually in additional regional personal income benefits and support up to 25,000 new family wage jobs.[11]

For ocean fisheries, about 32% of the Chinook salmon in non-tribal commercial fisheries along the Washington and Oregon coasts consist of Columbia River stocks. Further north in Alaska and British Columbia, Columbia River Chinook salmon consist of 28% and 8% of the Chinook harvested respectively.[11] The restoration of Columbia Basin salmon has the potential to be an opportunity for the ocean salmon troll and Columbia River commercial fisheries to regain stability as both an industry and as an important local food production system. In addition to the direct benefits of the Pacific salmon fishery, additional jobs are indirectly generated by the salmon fishing industry and occur in smaller coastal communities whose economies are heavily dependent on the fishery. For example, the Astoria, Oregon, and Ilwaco, Washington port areas were important salmon processing centers, and declining harvests in the Columbia River commercial fishery have led to major declines in these industries.[11] From 2010 to 2019 the Pacific commercial salmon fishery saw a decrease of 41% in commercial revenues in real terms and a 64% decrease in commercial landings.[64] The dire population levels for Snake River salmon also significantly restrict tribal and non-tribal harvest of more healthy populations of Columbia Basin salmon and steelhead.

For the Southern Resident orca, increases in overall Chinook salmon abundances, including Snake River Chinook, could help increase prey availability. Southern Resident orca are declining due to a combination of three limiting factors: (1) prey availability, (2) vessel noise and disturbance, and (3) toxic contaminants. Although Southern Resident orca consume a variety of fish and one species of squid, salmon are their primary prey, particularly Chinook salmon. Depending on the season, Chinook can account for 50% to 100% of the orca's diet. In mid-winter/spring, the time corresponding to Southern Resident's highest use of coastal waters, Chinook salmon can represent 70% to 80% of their diet.[12] Chinook salmon from the Columbia Basin regularly account for more than half of the total salmon consumed by Southern Residents. Recent research indicates that as salmon populations have decreased within the Southern Resident's traditional summer feeding grounds in the Salish Sea, Columbia Basin Chinook salmon has become a large proportion of their annual diet.[13] NOAA has stated, "perhaps the single greatest change in food availability for resident killer whales since the late 1800s has been the decline of salmon in the Columbia River."[14] While there was a small improving trend for Columbia Basin Chinook salmon from very low returns in 2018 to somewhat higher returns 2020, Southern Resident orca still experienced energy deficits due to lack of prey availability.[13]

Change in the Lower Snake River and the Columbia River system is inevitable

In the ongoing conversations about the LSRD, the question is often presented as: "Should the dams be breached, or should we maintain the status quo?" This binary framing ignores that change has already come to the LSRD system and will continue. For example, recent trends toward reduced summer and fall flows for the LSRD due to increased drought and reduced snowpack puts practical constraints on river operations and the power and capacity functions of the dams. The LSRD contribution to the rapidly changing energy system will fluctuate annually depending on environmental factors such as river flow, and others such as energy market conditions. Snake River salmon populations are projected to continue declining, and federal courts may further restrict the energy production flexibility of the LSRD in response to those declines through increased spill and other operational constraints, which may affect navigation reliability as well. In addition to changes in the system resulting from increasing spill, there will be changes in system operations to meet water temperature standards and other requirements to protect water quality for native in-river species.[15]

After over 20 years of implementing mitigation and restoration actions for Snake River salmon and steelhead species, the species are on a downward trajectory. Despite robust levels of assessment and planning, actions have not resulted in responses that would indicate adequate mitigation, let alone levels of recovery. Hatcheries and mainstem fish passage structures require increased funding to achieve existing mitigation goals and future recovery and rebuilding objectives. Habitat actions will require additional support to address the significant and ongoing impacts of human development, including climate change. Even if the dams are retained, the Pacific Northwest and the citizens of the US will have to address the significant cost associated with the backlogged known, necessary work, plus the additional cost to achieve regional mitigation and species rebuilding goals.

Within the Snake River Basin, most climate change projections indicate greater warming than other regions in the Columbia River Basin, and on average summer flow volumes are expected to decrease. However, there is uncertainty within climate change projections on summer precipitation levels and extreme low flows are expected to have little change or small increases in severity. Precipitation is expected to increase and result in higher fall and winter flows and earlier and higher spring flow peaks. Models suggest that as early as the 2030s, snowpack in the Snake River Basin is likely to decrease with streamflow timing changes appearing earlier here than other parts of the Columbia River Basin.[16] The NWPCC projects under expected economic conditions without additional clean energy policy legislation that combined climate change impacts on loads and hydropower may lead to decreases in winter shortfalls, and increases in summer shortfalls as increases in peak loads for cooling coincide with decreases in hydropower generation due to lower river flows.[99] Those models, and the Washington state utilities that also model the LSRDs in their long-term plans, include the contributions of the LSRD to help meet all seasonal needs. New analysis comparing the high electrification of transportation, buildings, and industry with the NWPCC's projections resulted in an additional annual energy demand increase of 28% by 2045 and an additional winter peak demand increase of 68% above the NWPCC's projections.

Estimates of the impact on greenhouse gas emissions if the LSRD are breached vary depending on the models and assumptions used to generate the estimates, as well as future decisions related to the energy and transportation system. Some estimates show a significant increase in greenhouse gas emissions while others indicate a potential decrease. The State of Washington has moved forward with policy and legislation to reduce greenhouse gas emissions across multiple sectors of the economy. This has created a dynamic situation in the energy, transportation and buildings sectors as key stakeholders work through their planning processes and reconfigure their activities to meet the state's greenhouse gas reduction goals. This evolving context creates additional uncertainty that must be factored into future decisions.

Current LSRD services and benefit replacement actions

The LSRD services and related economic benefits for navigation and transportation, irrigated agriculture, energy, and tourism and recreation are described in the specific topical sections in the report and are briefly summarized here, along with the principal actions for replacing the benefits or mitigating their loss.

- **Navigation and transportation:** The LSRD enable low-cost shipping of agricultural products, primarily wheat, via barge. Barge rates average 30 cents to 45 cents per bushel of wheat versus other methods, such as rail which ranges from 50 cents to 75 cents per bushel.[17] Breaching the LSRD would eliminate all commodity barging between the Tri-Cities and Lewiston-Clarkston causing that transportation to shift to regional rail and trucking networks. Most studies conclude that if barging on the lower Snake were eliminated rail would become the predominant regional transportation mode, with trucking as the next most predominant mode. Given the estimated changes in rail and truck transportation significant improvements would be required to expand and upgrade shortline rail networks as well as local and state roadways. Compensation for increased transportation costs, infrastructure maintenance and loss of jobs would need to be considered.
- **Irrigation:** Irrigators use the reservoirs and elevated groundwater levels created by the LSRD to pull water for irrigation. The combined production value of irrigated land along the Snake River in 2021 was estimated to be $327.89 million (AgriNorthwest, pers. comm., April

19, 2022). The 2020 CRSO EIS estimates that irrigated agriculture supported by the LSRD contribute $232 million in labor income and $460 million in sales.[18] If the LSRD were breached, a variety of replacement actions have been identified to maintain the services provided by the LSRD to irrigated lands and the surrounding agricultural community. These actions include deepening of wells and modifications to pumping infrastructure to accommodate the lower water table and modifying surface water withdrawal infrastructure such as intake structures and pumping capacity.

- **Energy:** The LSRD are part of the broader integrated system of hydroelectric facilities on the Columbia River and its major tributaries. The energy services currently provided by the LSRD include annual energy production, peaking capacity, clean energy, grid stability, ancillary and grid services, transmission services and lower regional energy rates. The LSRD contribute to the energy provided by the Bonneville Power Administration (BPA). There are multiple studies of potential LSRD replacement portfolios, though their methodologies and some of their conclusions vary significantly. These studies found the energy generated by the LSRD could be replaced by a clean energy portfolio that would rely primarily on increased solar and wind generation, energy storage, energy efficiency, and demand response. The studies vary in their assumptions about when resources will be available for replacement and the relationship to state's clean energy mandates. Replacing the energy production of the LSRD would take time, funding, planning and collaboration across all stakeholders to ensure that the region's future clean energy goals are met, the region maintains a reliable system, and customers, especially the most vulnerable, are not overly burdened by increased electricity rates. The replacement portfolio must be in place and demonstrating that it is producing energy and providing services to the grid before breaching of the dams to avoid significant impacts to the regional energy system and the communities it serves.
- **Recreation.** The LSRD enable flatwater recreation and cruise industry operation along the Snake River. The LSRD currently support 2.6 million water- and land-based recreational visits annually.[19] The cruise industry had an economic impact of approximately $4 million in 2019 and is projected to increase in the coming years.[20] Significant investment for recreational facilities and compensation for impacted industries would be required if the dams were breached. There would be a need for redevelopment of the waterfront in Lewiston and Clarkston as well as other recreational facilities along the current reservoir areas, and development of new recreational opportunities consistent with a free-flowing river.

With advance planning and investment, the services the LSRD provide could be fully or partially maintained for multiple industries and sectors, and negative impacts of dam breaching could be mitigated. However, some industries will be fundamentally altered if the LSRD were breached. These include tourism impacts from the loss of cruise boats in and out of the Lewis-Clark Valley and broader region, commerce at the Lewiston and Clarkston Ports, and industries associated with barge transportation along the lower Snake River. To a certain extent, impacts to some of these industries can be mitigated. It is clear that prior to breaching additional work would be needed to identify broader impacts to the local community and actions that can be taken to maintain and enhance economic vitality in the region.

Costs of retaining the dams

If the dams are not removed, the costs to operate and maintain the dams will change into the future. Just as there would be significant costs associated with dam removal, there would also be significant costs associated with choosing to keep the dams. The list below includes examples of key cost centers if the dams are retained, many of which have not been quantified:

- Ongoing operation and maintenance costs for LSRD
- Capital investments for LSRD infrastructure
- Funding for current LSRD mitigation actions, including hatchery production commitment fulfillment and increased hatchery capacity and production to address abundance goals and climate change impact mitigation needs
- Funding for lower Snake River stock abundance rebuilding
- Transportation system operations and maintenance, including dredging
- Potential financial impacts of judicially ordered spill to decreased energy production, grid resiliency and transportation
- Unplanned or unanticipated costs to prevent increasing salmon decline and extinction (e.g. expedited captive brood program)

A decision to maintain the dams could also necessitate a significant near-term investment in a comprehensive and realistic strategy for achieving the Columbia River Partnership mid-level goals as identified by NOAA Columbia Basin Partnership and supported by the Northwest Power and Conservation Council. Longer-term funding commitments would also be needed to move towards Columbia Basin Partnership high-level goals.

While not meant to be entirely comprehensive, Table 1 summarizes the estimated annual and present value costs of keeping the LSRD over a 50-year timeframe. The present value of these costs is $4.50 billion to $8.35 billion and includes operations and maintenance costs, capital investments, and fish and wildlife mitigation program costs, with all of these cost estimate sources from the CRSO EIS or BPA. Other costs associated with maintaining the dams have not been quantified but could significantly add to future costs.

The current operation and maintenance costs for the LSRD are about $83 million[AC] annually,[21] which is subsidized by the federal government and regional ratepayers. The present value cost of LSRD operation and maintenance over a 50-year timeframe is $2.5 billion. All four LSRD are near or over 50 years old, have had previous scheduled maintenance and equipment upgrades made to their infrastructure, and have some level of future scheduled investment. As of 2022, BPA plans to spend about 12% of their forecasted total capital investments over the next 50 years on the LSRD, equivalent to roughly $30 million to $42 million annually.[22] The present value cost of these BPA capital investments would range from $895 million to $1.25 billion.[DH] The differential Fish & Wildlife Mitigation Program costs between a breaching scenario and the preferred alternative range from $0 to $116 million annually.[DI] The present value cost of these Fish & Wildlife Mitigation Program costs range from $0 to $3.5 billion.[DJ] Finally, if the LSRD were to be breached, it is projected that there would be an annual reduction of $37 million[DK] in hatchery operations and maintenance costs associated with the LSR Compensation Plan (LSRCP) facilities. The present value over 50 years of these LSRCP costs is $1.1 billion.[DL]

Table 1: Estimated annual and 50-year costs of keeping the LSRD that have been quantified

Cost item	Annual Estimated Cost	50-year Estimated Cost
LSRD operation & maintenance	$83 million per year	$2.50 billion
LSRD capital investment	$30 million to $42 million per year	$895 million to $1.25 billion
LSRD Fish & Wildlife Mitigation Program	$0 to $116 million per year	$0 to $3.50 billion
LSRCP hatchery operations & maintenance costs	$37 million per year	$1.10 billion
Total	**$150 million to $278 million per year**	**$4.50 billion to $8.35 billion**

Summary of overall replacement and mitigation costs

The research, outreach, drafting and finalizing of this report was conducted over approximately seven months including a 30-day public comment period on the draft report. It summarizes information from previous analyses and documents and, where possible, updates the information from previous work based on expert interviews. There is a wide range in the level of detail in previous analyses. For example, the 2020 CRSO EIS was developed over four years costing $50 million and involved technical experts, the input of thousands of individuals via public comment and meetings, scientific models, and detailed economic analyses. In contrast, the Simpson Proposal was based on discussions with several hundred individuals representing various interests in the LSRD to generate order of magnitude cost estimates for replacement of the services provided by the dams. A number of different reports described in this report were commissioned by various advocacy groups, some issued during the development of this report. In this report, we note the different sources and their respective assumptions to provide appropriate context for the wide range in cost estimates.

Based on previous studies, replacing the services provided by the dams could range in cost from $10.3 billion to $31.3 billion (see Table 2), and anticipated costs are still not available for several necessary actions, including long-term operations and maintenance. There was a wide range in the level of detail and assumptions for the analyses used to develop cost estimates. For example, the cost for energy replacement varies greatly depending on a number of issues including the source of energy, technological advances, location of new sources and many other factors. If breaching were to move forward, all cost estimates would need to be refined through additional technical work and collaboration with affected parties.

All dollar values are expressed in April or May 2022 values unless otherwise noted. The dollar values from the original reports were adjusted to 2022 dollars using a variety of price indices, including the Bureau of Economic Analysis's GDP Price Deflator, the Engineering News-Record Construction Cost Index, the Bureau of Reclamation's Operation and Maintenance Cost Index, and sector-specific producer price indices. To highlight costs in total present value terms (the value in today's dollars of the stream of expected costs over the next 50 years), the analysis uses a 50-year time horizon and the federal water resources planning rate of 2.25%.

Table 2: Summary of LSRD estimated replacement and mitigation costs across categories

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
Energy	Energy Replacement	CRSO EIS	$9.3 billion - $18.6 billion	The low-cost estimate is for the Least Cost portfolio and the high-cost estimate is for the Zero Carbon Portfolio. Includes capital and operating costs, transmission upgrades, and demand response
Energy		Energy Strategies (2022)	$8.3 billion to $9.3 billion	The low-cost estimate is for the BPA Net Position portfolio and the high-cost estimate is for the BPA Load Shape portfolio. Includes capital and operating costs of renewable energy portfolios Does not include transmission upgrades, grid connection costs, or other system upgrades (anticipated by the authors to be small)
Energy		E3 (2022)	$13.0 billion to $22.7 billion	The low-cost estimate is for the Scenario 1a portfolio and the high-cost estimate is for the Scenario 2a portfolio Costs represent those required for firm capacity power replacement Includes transmission costs The low-end value assumes emerging technologies become commercially viable. The report also includes a high-cost estimate of $49 billion to $89 billion. These high-end values assume no combustion resources and no technological breakthroughs for emerging technologies, and high increased electricity loads due to increased electrification.

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
Energy		Energy GPS (2022)	$41.5 billion to $56.9 billion	Costs represent the cost of constructing 14.9 GW of name plate resources due to assumed low effective capacity rates that only 9% to 12% of the new resources can be utilized to meet demand. Does not include costs for transmission, increased electrification, or land use/permitting of new infrastructure, or emergence of new technologies. The Energy GPS report estimates $15 billion costs from 2030 to 2045 with annual recurring costs of $2.5 billion from 2046 – 2080 for replacing the energy of the lower Snake River Dams. The present value cost range of $41.5 billion to $56.9 billion reported is reflective of the way dollar values are presented throughout this report, i.e., a 50-year time horizon and the federal water resources planning rate of 2.25%
Energy		Simpson Proposal	$16 billion	Includes "Clean Firm Power Replacement", lower Columbia "Salmon Spill" replacement power, NW Grid Resiliency and Optimization
Breaching	Breaching the Dams	CRSO EIS	$1.24 billion	Includes the costs of breaching, revegetation, and cultural resources protection
Breaching		EcoNW	$1.37 billion	Includes dam removal, revegetation, mobilization and contingencies, and environmental mitigation
Breaching		Simpson Proposal	$2 billion	Includes the costs of breaching, sedimentation, revegetation, and cultural resources protection
Navigation & Transportation	Navigation & Transportation Mitigation	EcoNW	$542 million to $588 million	Includes costs to shipper, emission, accidents, road wear and tear, road infrastructure, and rail infrastructure
Navigation& Transportation		CRSO EIS	$969 million to $1.3 billion	Includes costs for road repairs and maintenance, a shuttle rail facility, rail infrastructure, rail and road armoring and dredging
Navigation& Transportation		FCS Group	$3.7 billion to $4.8 billion	Includes cost of replacing transportation benefits of dams, emissions, accidents, roadway maintenance, and direct farm payments
Navigation& Transportation		Simpson Proposal	$4.5 billion	Includes cost of infrastructure upgrades to ports, rail, and roads; payments to shippers
Irrigation	Irrigation Infrastructure Mitigation	2002 Army Corps EIS	$1.0 billion ($787 million capital cost, $218 million in present value	Deepen 71 wells, create a common pump station for Ice Harbor irrigators, and maintain annually surface water withdrawal.

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
			of annual maintenance cost)	
Irrigation		EcoNW	$188 million	Deepen wells and modify related infrastructure and mitigate for 41 surface water withdrawals along the Snake River.
Irrigation		Simpson Proposal	$750 million	Complete any structural changes required for affected irrigation intakes, outflows, wells or other structures related to irrigation along the lower Snake River
Recreation	Recreation infrastructure Mitigation	Simpson Proposal	$425 million	National Recreation Area development, tourism promotion, sportfishing fund, relocation of marinas, compensation of motorized boat owners
Economic Development	Investment in Lewis-Clark Valley	Simpson Proposal	$325 million	Lewiston-Clarkston waterfront restoration, general economic development funds
Total	**Total costs all mitigation measures**	**Low estimates in each category added together. High estimates in each category added together.**	**$10.3 billion to $31.3 billion**	**Low end estimate does not include Simpson Proposal for recreation and community development.** **High end cost estimate does not include the high-cost estimate from the E3 report or the Energy GPS findings for energy replacement due to the substantial amount of replacement resources these studies call for compared to other comparative studies. The Energy GPS study determined that 15GW of replacement resources were necessary to maintain reliability and the high-cost scenario for the E3 study determined that 13GW was necessary, both values of which are four to five times larger than the replacement capacities determined in the CRSO EIS (3.5GW). Additionally, Senator Murray and Governor Inslee have determined an energy replacement portfolio only relying on intermittent resources is not a valid path forward.**

Given the potential magnitude of these costs, significant federal investment will be needed. Funding from the recently enacted Infrastructure Investment and Jobs Act, for example, could be applied to defray the costs of road, rail, and water infrastructure, and provide economic development through improvement of broadband services.

1. Context and Purpose

Context and purpose

Over the past several decades, the LSRD and their impacts on salmon and Pacific lamprey have been the subject of numerous scientific and environmental analyses, task forces, and reports. Much of this work occurred as part of the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) biological opinions (BiOps) dating to the early 1990s. Other task forces and proposals at the state and federal levels associated with the LSRD include the 2017 Columbia Basin Partnership Task Force, the 2018 Southern Resident Orca Task Force, and the March 2020 Lower Snake River Dams Stakeholder Engagement Report. In December 2018 representatives of the states of Oregon and Washington, the Nez Perce Tribe, BPA, Army Corps, and the Bureau of Reclamation signed an agreement for flexible spill operations on the Snake River and lower Columbia dams to aid juvenile fish passage. In July 2020 the Army Corps released the Columbia River System Operations Final Environmental Impact Statement (CRSO EIS). The preferred alternative identified in the CRSO EIS is a combination of measures from the various alternatives examined and includes components from the flex spill agreement but does not include dam breaching. Following the release of the CRSO EIS, the Nez Perce Tribe, State of Oregon and 11 fishing and conservation groups challenged the decision in U.S. District Court. Early in 2021, Idaho Congressman Mike Simpson announced the Columbia Basin Initiative. In October 2021, parties agreed to pause litigation until July 2022 to allow time for the parties to develop, work to reach agreement on, and begin implementing a long-term, comprehensive solution to Snake River salmon and broader Columbia Basin salmon restoration. In early August 2022, the parties agreed, with the federal district court's approval, to extend the litigation pause until August 31, 2023.

In May 2021, Governor Jay Inslee and Senator Patty Murray announced a joint federal-state process to determine whether there are reasonable means for replacing the services and benefits provided by the LSRD sufficient to support dam breaching as part of a comprehensive salmon recovery strategy for the Snake River and the Pacific Northwest. The Ross Strategic/Kramer Consulting team was retained in November 2021 and began work in January 2022.

1991: Snake River Sockeye ESA listing

1994: NOAA biological opinion struck down in OR District Court

1995: NMFS issues proposed recovery plan for Snake River salmon

1997: Snake River Basin steelhead ESA listing

2002: Lower Snake River Juvenile Salmon Migration Feasibility Report/EIS; examines alternatives for improving salmon migration through the LSRD

2017: Columbia Basin Partnership Task Force develops shared goals & comprehensive vision for future of Columbia Basin anadromous fish

NOV 2018: Southern Resident Orca Task Force develops recommendations for orca recovery and future sustainability, including recommendations directly related to the LSRD

DEC 2018: Flex Spill Agreement signed

MAY 2020: Lower Snake River Dams Stakeholder Engagement Report; describes a range of perspectives on breaching the LSRD & opportunities for increased understanding

JUL 2020: USACE releases Columbia River System Operations Final Environmental Impact Statement (CRSO EIS)

OCT 2020: Columbia Basin Partnership Task Force report identifies goals for improving salmon & steelhead runs in Columbia River Basin

FEB 2021: Idaho Congressman Mike Simpson announces Columbia Basin Initiative, proposal to breach LSRD for salmon recovery

OCT 2021: Litigation around the CRSO EIS paused until Jul 2022, to allow to develop & begin implementing a long -term comprehensive solution to resolve all claims in the litigation

OCT 2021: Governor Inslee and Senator Murray announce joint federal -state process for examining cost of replacing LSRD benefits

NOV 2021: President Biden signs $1.2 trillion Infrastructure Investment & Jobs Act

AUG 2022: The parties agreed, with the federal district court's approval, to extend the litigation pause until August 31, 2023

Biological Opinions: 1993, 1995, 2000, 2004. 2008, 2014

Key Points of Litigation Related to Biological Opinions

Methodology

Information for this report was gathered through a combination of literature and document review, telephone and online interviews and discussions, and an online feedback form. During the literature review, the project team assembled and reviewed publicly available information from recent studies and task forces described above to understand perspectives on the services and benefits provided by the LSRD, document potential means to replace those services and benefits were the dams to be breached and compile associated cost estimates. The consultant team also engaged with Washington state agencies to gather feedback or make use of their respective topical area expertise.

Interviews were carried out with tribal sovereigns, stakeholders, advisors and experts from across the region who have experience and expertise with the issues surrounding the benefits, effects, and concerns with retaining or breaching the LSRD, as well as opportunities to provide similar or better services if the dams were to be breached. Most of the interviews were conducted with a two-member team. Some calls were conducted with one individual, whereas others were group interviews. To encourage interviewees to be as candid as possible, this report does not attribute specific statements to individual interviewees unless interviewees approved their attribution. In some cases, the consulting team had email or phone communications and provided briefings on the report to groups or individuals. Appendix A is a list of all individuals contacted for this report.

This report uses endnotes for references. The first time a new source is referenced it is given a numerical endnote (e.g., [1, 2, 3,] etc.), and if that same reference is used again throughout the report it uses the same numbered endnote. All references are listed in a References section at the end of the report.

To complement the literature review and interviews, an online feedback form was posted on the project website (https://www.lsrdoptions.org/) to gather additional public information on the benefits currently provided by the LSRD and the opportunities to provide similar or better services if the dams were to be breached. The online feedback form stayed open through May 20, 2022. A total of 2,694 responses were received through the feedback form and the results were considered as the draft report was developed. A copy of the online feedback form questions is provided in Appendix B. Note that the results of the questionnaire were not intended for use in any statistical analysis.

The research, outreach, drafting and finalizing of this report was conducted over approximately seven months including a 30-day comment period on the draft report. It summarizes information from previous analyses and documents and, where possible, updates the information from previous work based on expert interviews. There is a wide range in the level of detail in previous analyses. For example, the 2020 CRSO EIS was developed over four years costing $50 million and involved technical experts, scientific models, the input of thousands of individuals via public comment and meetings, and detailed economic analyses. In contrast, the Simpson Proposal was based on discussions with several hundred individuals representing various interests in the LSRD to generate order of magnitude cost estimates for replacement of the services provided by the dams. A number of different reports described in this report were commissioned by various advocacy groups, some of which were issued during the development of this report. In this report, we note the different sources and their respective assumptions to provide appropriate context for the wide range in cost estimates.

All dollar values are expressed in April or May 2022 values unless otherwise noted. The dollar values from the original reports were adjusted to 2022 dollars using a variety of price indices, including the Bureau of Economic Analysis's GDP Price Deflator, the Engineering News-Record Construction Cost Index, the Bureau of Reclamation's Operation and Maintenance Cost Index, and sector-specific producer price indices. For every dollar value updated to 2022 dollars the report includes a letter superscript (e.g., [A, B, C,] etc.), and information on the index and methodology used for each adjusted dollar value is provided in Appendix C. To highlight costs in total present value terms (the value in today's dollars of the stream of expected costs over the next 50 years), the analysis uses a 50-year time horizon and the federal water resources planning rate of 2.25%.

Public comment process

The draft report was available for public review from June 9, 2022, through July 11, 2022. Public comments were collected online and by mail. Online comments were provided through a form at www.lsrdoptions.org and comments by mail were submitted electronically (email to info@lsrdoptions.org) or by paper mail.

By the end of the public comment period, the consultant team received approximately 1,769 online form submissions, 22 comments via mail, and approximately 65,000 emails and attachments. The public could submit as many comments as desired within the 30-day comment period, and as such the number of responses does not necessarily represent the number of individual commenters. Appendix D summarizes the major themes of public comments received on the draft.

Report overview

The remainder of this report is divided into the following sections and topics:

- **Section 2** summarizes changes that have already occurred to the LSRD system and the changing context surrounding the dams regardless of the breaching debate
- **Section 3** provides an overview of dam breaching, including a definition, assumptions, costs, and additional activities, such as habitat restoration, associated with dam breaching that would be needed to realize the full benefits of the action
- **Section 4** describes the historic impact of the dams and potential implications of breaching the LSRD, particularly for salmon and tribal nations
- **Sections 5-10** discuss various social, economic, and environmental issues related to the LSRD. Each section includes a summary of the existing benefits that the LSRD provide, impacts if the LSRD are breached, and actions needed to replace or improve the benefits the dams currently provide, including cost estimates where available. The sections are:
    - Section 5: Navigation and Transportation of Grain and Other Commodities
    - Section 6: Emissions Impacts
    - Section 7: Irrigated Agriculture
    - Section 8: Energy Replacement
    - Section 9: Tourism and Recreation
    - Section 10: Economic Impacts & Opportunities
- **Section 11**: Summary of Overall Replacement and Mitigation Costs

2. Change in the Lower Snake River and the Columbia River System Is Inevitable

In the ongoing conversation about the LSRD a question often presented is should the dams be breached, or should things remain the same? This framing ignores the important context that change has already come to the LSRD system and will continue.

From 1980 to 2018, BPA spent just under $25 billion[A] towards its Fish and Wildlife program to aid in the restoration of the ESA listed salmon that inhabit the river, including configuration and operational changes to the dams.[23,24] Of this investment, from 2011 to 2021, $561.5 million was spent on hatcheries as a part of BPA's legal obligations under the Norwest Power Act, Endangered Species Act (ESA), and other laws put in place to protect, mitigate and enhance fish populations affected by the construction and operation of the federal hydrosystem.[25] One of the primary measures that has been implemented for the benefit of salmonids has been spring and summer spill, during which a portion of water from a dam's reservoir is sent through spillways as opposed to through the powerhouses. Salmon mortality increases with repeated encounters with powerhouses and decreased river velocity. Spill is intended to reduce this mortality and increase the number of fish that successfully out-migrate as juveniles and return to spawn as adults. Spill can both reduce the amount of water that is available for power generation and limit the amount that reservoirs can fluctuate to meet small changes in regional loads. Reductions in the overall amount of water used for generation and litigation on water temperature for the benefit of in-river species further constrain hydrosystem operations. Compounding these issues is the recent trend in the overall reduction of flow in the lower Snake River due to increased drought and reduced snowpack.[26]

In total, all three of these constraints, i.e., spill for the benefit of salmon, mandates on in-river water temperatures, and lower flows due to drought and reduced snowpack, reduce the flexibility for current and future hydropower operations for the LSRD. This in turn reduces the ability for the LSRD to produce peak generation levels and store water to achieve these sustained peaks.

If the LSRD remain in place, their contribution to the rapidly changing energy system in the future will not be the same as it is currently and will fluctuate annually depending on environmental factors, such as river flow, and others such as market conditions that are changing as more renewables are added to the system. Snake River salmon populations are expected to continue to decline, and federal courts may continue to further restrict the flexibility of energy production for the LSRD in response to those declines. From the tribes' perspective, the low energy prices in the Pacific Northwest come "at the expense" of salmon being able to survive through the Snake River. At the signing of the Treaties in 1855, the tribes fully shared in the wealth that was provided by the Columbia River. According to the federal courts, the Treaties guaranteed not only that the tribes would have access to their usual and accustomed fishing places, but also that there would be fish sufficient to sustain them. With the damming of the Snake River, the wealth of the Snake River has been transferred through energy production, transportation, and irrigation to the detriment of salmon and the communities that rely on salmon. The tribes' diminished access to their natural resources undermines their ability to maintain their culture, language, and religious ceremonies. The tribes currently have access to a fraction of a percent of the natural resources once provided by the Snake River at the time of signing the treaties.

Courts have consistently ordered dam operators to spill more water over the dams for the benefit of salmon at the expense of energy revenue generated by Bonneville Power Administration (BPA). The 2019-2021 Flex Spill Agreement, and current operations pursuant to settlement talks, built upon those court orders were agreed upon by multiple regional stakeholders which ordered increased spill for the benefit of salmon largely during non-peak load hours, to keep the average annual cost at no more than the cost of 2018 planned fish operations. However, the cost of spill prior to the 2019-2021 Flex Spill Agreement was already at the expense of energy production from the LSRD and Columbia River dams and revenue generated by BPA. The BPA Fish and Wildlife Cost Reports show the annual cost of foregone hydropower sales and power purchases associated with fish operations as a portion of the overall cost of fish and wildlife mitigation. These cost estimates fluctuate annually depending on the water year and energy markets but have averaged just under $200 million per year from 2011 to 2020.[23] The flex spill fish operations continue to date as components of the preferred alternative in the 2020 FCRPS BiOP, but these operations have recently been challenged as insufficient in federal court, and additional spill above the 2020 BiOP flex spill operation was required in Spring 2022 through an agreement to pause the BiOp litigation. Potential court-ordered or negotiated reductions in reservoir levels could also affect the ability to support navigation on the lower Snake River by barges and cruise ships.

If litigation and court decisions require operational changes similar to alternative MO4 (Maximum Spill) in the CRSO EIS, "hydropower generation could decrease by 1,300 average Megawatts (aMW) under average water conditions, and 870 aMW under low water conditions compared to the No Action Alternative, the largest impacts on hydropower generation of any of the alternatives. The primary reason for the reduced generation is the increase in juvenile fish passage spill, up to 125% total dissolved gas levels 7 days a week, 24 hours a day from March 1 to August 31, with most lower Snake and lower Columbia River projects operating at minimum generation levels in the majority of water conditions. This increase in spill, together with a measure that provides dry-year augmentation of spring flow with water stored in upper basin reservoirs, contributes to MO4 having the highest probability of power shortages of any of the MOs, with blackouts or emergency conditions in roughly one in three years (pg. 35)."[9]

Several experts interviewed referenced the situation in the Klamath River Basin on the border of Oregon and California where four dams are slated to be removed in 2023 (Oregon Department of Fish and Wildlife and Greater Hells Canyon Council, pers. comm., February 2022; Nez Perce Tribe, pers. comm., March 3, 2022). Somewhat similar to the process that has unfolded for the LSRD, the basin engaged in a series of agreements between all stakeholders on the four privately owned Klamath dams that aimed to balance environmental, agricultural, tribal and fishery needs from the early 2000s through the mid-2010s. Just like with the agreements that were reached on the LSRD, multiple parties believed that past agreements for the Klamath River did not provide sufficient resources for ESA listed species and did not affect the implementation of the ESA. Ultimately the parties came together on the Klamath Basin Settlement Agreement in 2016 which agreed upon the removal of the four projects through the traditional Federal Energy Regulatory Commission approval process.

Within the Snake River Basin, most climate change projections indicate greater warming than other regions in the Columbia River Basin, and on average summer flow volumes are expected to decrease. However, there is uncertainty within climate change projections on summer precipitation levels and extreme low flows are expected to have little change or small increases in severity. Precipitation is expected to increase and result in higher fall and winter flows and earlier and higher spring flow peaks. Models suggest that as early as the 2030s, snowpack in the Snake River Basin is likely to decrease with streamflow timing changes appearing earlier here than other parts of the Columbia River Basin.[27] The NWPCC projects under expected economic conditions without additional clean energy policy legislation that combined climate change impacts on loads and hydropower may lead to decreases in winter shortfalls, and increases in summer shortfalls as increases in peak loads for cooling coincide with decreases in hydropower generation due to lower river flows.[99] Those models, and the Washington State utilities that also model the LSRDs in their long-term plans, include the contributions of the LSRD to help meet all seasonal needs. New analysis comparing the high electrification of transportation, buildings, and industry with the NWPCC's projections resulted in an additional annual energy demand increase of 28% by 2045 and an additional winter peak demand increase of 68% above the NWPCC's projections. The peak demand increase is high due to the electrification of space heating end uses, which requires replacing significant quantities of energy currently provided by gas systems during extreme wintertime cold weather events with electricity.

Costs of retaining the dams

If the dams are not removed, the costs to operate and maintain the dams will change into the future. Just as there would be significant costs associated with dam removal, there would also be significant costs associated with choosing to keep the dams. The list below includes examples of key cost centers if the dams are retained, many of which have not been quantified:

- Ongoing operation and maintenance costs for LSRD
- Capital investments for LSRD infrastructure
- Funding for current LSRD mitigation actions, including hatchery production commitment fulfillment and increased hatchery capacity and production to address abundance goals and climate change impact mitigation needs
- Funding for lower Snake River stock abundance rebuilding
- Transportation system operations and maintenance, including dredging
- Potential financial impacts of judicially ordered spill to decreased energy production, grid resiliency and transportation
- Unplanned or unanticipated costs to prevent increasing salmon decline and extinction (e.g., expedited captive brood program)

A decision to maintain the dams could also necessitate a significant near-term investment in a comprehensive and realistic strategy for achieving the Columbia River Partnership mid-level goals as identified by NOAA Columbia Basin Partnership and supported by the Northwest Power and Conservation Council. Longer-term funding commitments would also be needed to move towards Columbia Basin Partnership high-level goals.

While not meant to be entirely comprehensive, Table 1 summarizes the estimated annual and present value costs of keeping the LSRD over a 50-year timeframe. The present value of these costs is $4.50 billion to $8.35 billion and includes operations and maintenance costs, capital investments, and fish and wildlife mitigation program costs, with all of these cost estimate sources from the CRSO EIS or BPA. Other costs associated with maintaining the dams have not been quantified but could significantly add to future costs.

The current operation and maintenance costs for the LSRD are about $83 million[AC] annually,[28] which is subsidized by the federal government and regional ratepayers. The present value cost of LSRD operation and maintenance over a 50-year timeframe is $2.5 billion. All four LSRD are near or over 50 years old, have had previous scheduled maintenance and equipment upgrades made to their infrastructure, and have some level of future scheduled investment. As of 2022, BPA plans to spend about 12% of their forecasted total capital investments over the next 50 years on the LSRD, equivalent to roughly $30 million to $42 million annually.[22] The present value cost of these BPA capital investments would range from $895 million to $1.25 billion.[DH] The differential Fish & Wildlife Mitigation Program costs between a breaching scenario and the preferred alternative range from $0 to $116 million annually.[DI] The present value cost of these Fish & Wildlife Mitigation Program costs range from $0 to $3.5 billion.[DJ] Finally, if the LSRD were to be breached, it is projected that there would be an annual reduction of $37 million[DK] in hatchery operations and maintenance costs associated with the LSR Compensation Plan (LSRCP) facilities. The present value over 50 years of these LSRCP costs is $1.1 billion.[DL]

Table 3: Estimated annual and 50-year costs of keeping the LSRD that have been quantified

Cost Item	Annual Estimated Cost	50-year Estimated Cost
LSRD operation & maintenance	$83 million per year	$2.5 billion
LSRD capital investment	$30 million to $42 million per year	$895 million to $1.25 billion
LSRD Fish & Wildlife Mitigation Program	$0 to $116 million per year	$0 to $3.50 billion
LSRCP hatchery operations & maintenance costs	$37 million per year	$1.10 billion
Total	**$150 million to $278 million per year**	**$4.50 billion to $8.35 billion**

3. Dam Breaching and Removal: Definition, Assumptions, and Costs

This section describes three types of costs associated with dam breaching and removal that are not described in the chapters specific to different services currently provided by the dams: (1) the direct costs associated with the physical breaching and related removal of breached dam structures, (2) preparatory costs covering activities such as alternate fish passage facilities that would need to be completed before dam breaching, and (3) costs of restoration and management in the lower Snake River following dam breaching and removal.

This report uses the dam breaching definition and assumptions described in the 2020 CRSO EIS. Dam breaching is defined as removal of "the earthen embankments, abutments, and portions of existing structures at the dams to eliminate the reservoirs behind the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects (pg. 2-57)."[29] Drawdown and structure removal would occur over a projected two-year period, be designed to minimize disruption or damage to reservoir-adjacent infrastructure and be timed to minimize impacts to ESA-listed salmon.

Pre-dam breaching activities

This report assumes that all necessary actions described in the 2020 CRSO EIS will be completed prior to reservoir drawdown and dam breaching and removal, including modifying equipment and infrastructure at each of the LSRD to adjust to drawdown conditions, primarily turbine modification to allow maximum water discharge. Other pre-drawdown and breaching actions would occur within the Columbia River system, such as constructing additional powerhouse surface passage routes and juvenile fish detectors at McNary Dam, installing new adjustable spillway weirs at lower Columbia dams where needed, expanding the lamprey passage structure network and installing new turbines at John Day Dam. Some of these actions at lower Columbia River dams may occur irrespective of whether LSRD breaching occurs.

Municipal and industrial water pump stations near the Lower Granite Pool will require modification if the LSRD were to be breached.[30] These include local golf courses, backup pump stations for Asotin County Public Utility District (PUD), and the Clearwater Paper Mill in Lewiston, Idaho. A 1999 analysis by the Drawdown Regional Economic Workshop (DREW) estimated the cost of modifying these pump stations between $25 million and $121 million[AE]. The largest share of this cost is modifying the water systems for the Clearwater Paper Mill, where the estimate ranges between $24 million and $120 million[AF] depending on whether a discharge water cooling facility is needed.[30]

Direct costs of dam breaching

Breaching the LSRD would require significant advance investment in design and engineering for site preparation, dam breaching and removal, and post-removal actions. Estimates for the cost of breaching range from $1.24 billion[E] in the 2020 CRSO EIS, to $1.37 billion[F] from the

ECONorthwest report based on the Klamath River dam breaching,[31] to $2 billion[G] the Simpson Proposal.[32] Table 4 summarizes these cost estimates.

Table 4: Summary of LSRD breaching and removal cost estimates and assumptions.

Source	Cost Estimate	Key Assumptions
CRSO EIS (2020)	$1.24 billion	Includes the costs of breaching, revegetation, and cultural resources protection.
Simpson Proposal (2021)	$2 billion	Includes the costs of breaching, revegetation, and cultural resources protection.
ECONorthwest (2019)	$1.37 billion	Includes dam removal, revegetation, mobilization and contingencies, and environmental mitigation.

The cost estimates listed in the table above are just that – estimates. If breaching were to move forward, specific engineering, design and pre-construction work with more detailed cost analysis would be needed. These studies might increase the estimated cost, or they might decrease it. The 2020 CRSO EIS, for example, included conservative assumptions under worst-case scenarios with a 50% contingency built in. This planning also would need to address actions related to breaching but not directly included in some of the breaching estimates. For example, the 2020 CRSO EIS does not include potential cleanup costs for downstream contaminated sediments and possible water quality issues associated with drawdown.

Because the LSRD are part of the larger Columbia River hydroelectric system, changes in how the system is operated will be needed so it can continue to meet the multiple objectives identified in the 2020 CRSO EIS under the new conditions if the LSRD were to be breached. Under one 2020 CRSO EIS alternative this could include additional and modified fish passage at other hydropower projects, water management activities, and revised operations at existing dams. Examples suggested by the CRSO alternative to reduce impacts on hydropower and agriculture from LSRD breaching include reduced summer juvenile fish passage spill at McNary, John Day, and the Dalles Dams, updating water management operations at Libby Dam, increasing pumped irrigation from Lake Roosevelt, and allowing full pool operations at John Day Dam. Other proposals would enhance salmon passage measures at the lower Columbia River dams to complement the expected salmon benefits of LSRD breaching but suggest more actions regarding other dam operations in the region.

Post-dam breaching activities

Post-breaching, the 2020 CRSO EIS states that two to seven years is the estimated timeframe for coarser sands and gravels currently stored in the LSRD reservoirs to reach pre-dam bed elevations and for the Snake River to reach a new dynamic equilibrium condition, i.e., balance between water transport and sediment input.[33] In the interim, the lower Snake River topography will rapidly change. As the river recedes to its historic channel, the exposed banks and slopes may slide, and leftover sediment will dry out when exposed to the arid environment. Tributaries will likewise be impacted as the Snake River returns to a free-flowing state since many are currently inundated to varying degrees due to the LSRD reservoirs. Small streams feeding the lower Snake River that have limited water flows may need excavation to remove sediment earlier than natural conditions would allow to provide fish passage (WDFW, pers. comm. March 11, 2022). The 2020 CRSO EIS cites significant uncertainty in the timing and process of river restoration, which is highly dependent on the amount of water flowing through the system in the years following dam removal. In contrast, Nez Perce staff noted in discussions that experiences with dam breaching in other river systems, e.g., the Elwha River, as well as their own sediment sampling in the lower Snake River reservoirs indicated that sediment transport occurs more rapidly than anticipated (Nez Perce Tribe, pers. comm., February 24, 2022). If that is the case, the Snake River will return to its original channel relatively quickly following LSRD removal. Nez Perce staff found from their technical work that the original geologic structure of the riverbed is intact, and much of the sediment at the headwaters of the Lower Granite reservoir could be dredged in advance of breaching.

Columbia-Snake River Irrigators Association: Regional Alternative

In the fall of 2020, the Columbia-Snake River Irrigators Association (CSRIA) prepared a "Regional Alternative" proposal to current LSRD operations. Under the proposal, the Lower Granite and Little Goose reservoirs would be permanently drawn down to almost the level of spillway cresting, with structural modifications at the dams to maintain fish passage and water flow control while the Lower Monumental and Ice Harbor dams would remain in place at current power production levels. The impacts of the proposal would affect the power sector through the lost production at two of the dams, and the transportation sector due to loss of barging in the Lower Granite and Little Goose reservoirs. Drawdown would also affect some recreation facilities, such as boat ramps and other river access points. The proposal is intended to provide benefits to ESA listed Snake River fish while simultaneously maintaining benefits for irrigated agriculture. This alternative is outside of the consultant team's scope of work and would require significant technical and economic review for a comprehensive analysis.

Additional costs of dam breaching

In addition to the costs of actions needed prior to dam breaching and those associated with actual dam breaching, there are other cost considerations for habitat restoration, protection of cultural resources, and modifications to other infrastructure.

After dam removal, Nez Perce staff believe that the riverbanks will revegetate quickly. The 2020 CRSO EIS likewise expects rapid revegetation and that exposed areas will be reseeded using native species. Cost estimates in the 2020 CRSO EIS include $59 million[AG] for native plant restoration for arid lands along the Snake River and $58 million[AH] for planting wetland and riparian species along the newly exposed shoreline.[21] The Simpson Proposal includes $75 million[G] for a lower Snake River corridor restoration fund.[32] Nez Perce staff believe this is likely a high-end estimate, as the river's original bed is largely unchanged and circumnavigates the concrete structures.

Tribal artifacts and sites currently inundated by the lower Snake River reservoirs will require protection and safekeeping. In conversations with the Nez Perce staff, it was discussed that upon drawdown it may be necessary to conduct archaeological surveys to identify the location of known and unknown cultural sites and better understand the scope of what would need protection (Nez Perce Tribe, pers. comm. April 28, 2022). To act quickly, funds would need to be allocated and distributed early on to best position the tribes and relevant agencies to carry out actions necessary to scope the areas, develop a plan for protection, and carry out the plan as drawdown and breaching occur. The Simpson Proposal includes $125 million[G] for the protection, preservation and mitigation of any cultural and tribal historic resources that may be affected, exposed, harmed, damaged, removed or altered as a result of breaching.[32] The 2020 CRSO EIS estimates include $22 million[AI] for short-term protection of cultural resources post-breaching, and approximately $1 million[AJ] annually thereafter.[21] Based on tribal experience in other areas of the Columbia River system and the 2020 CRSO EIS analysis, Nez Perce staff believe the Simpson Proposal estimate is reasonable. For comparison, when the Wanapum Reservoir was drawn down for repairs between February 2014 and March 2015, Grant County PUD spent almost $500,000[AK] per month on enforcement to protect tribal sites from pilfering, but the size and scope of protection necessary in the event of breaching the LSRD would be much greater.[34] There is strong support among the Columbia River tribes for a significant tribal consultative role in whatever management regime is used for the river corridor after breaching, such as Wild and Scenic River, National Recreation Area, or other designation.

Production from Columbia-Snake River hatchery operations would continue following LSRD removal as a significant mitigation component for the remaining dams and as a strategy for achieving de-listing from the ESA. The LSRD have contributed to salmon extirpation in many Snake River tributaries. Fish management programs will need to use hatcheries and broodstock to produce fish for reintroduction to these areas. Monitoring as part of fish management also will continue and require modification, such as relocating adult trapping from Lower Granite to McNary Dam and installing Passive Integral Transponders, or PIT, tag detectors at McNary and John Day spillways (WDFW, pers. comm., March 11, 2022). Other specific measures include changes to the Lyons Ferry Fish Hatchery at the confluence of the Snake and Palouse Rivers, which will require structural modifications such as deeper groundwater wells, support for the water supply line, and changes to the adult collection ladders and juvenile release systems. An engineering analysis will be needed to provide an accurate cost estimate for these modifications.

Several additional analyses are needed to further narrow the range of costs and effort required to prepare for LSRD breaching, implement the breaching itself and begin post-breaching actions. These include the engineering analysis and cost estimates at the Lyons Ferry Fish Hatchery, determining what modifications are needed at the Clearwater Paper Mill, and a detailed revegetation plan and accompanying cost estimate for the river corridor. Engineering analysis and cost estimates also may be needed for dredging small lower Snake River streams to ensure fish access post-breaching.

4. LSRD Impacts to Species, Tribes, and Fishing Communities Drive Interest in Breaching Option

Impacts to salmon and benefits from breaching

Impacts to salmon

The potential for improvements to salmon populations on the West Coast of the United States is the main factor prompting interest in breaching the LSRD.[35, 36] The lower Snake River is home to four ESA listed salmon species: spring/summer Chinook, fall Chinook, sockeye, and steelhead. It also is home to non-listed populations of anadromous coho which were extirpated in 1986 and reintroduced in 1994,[37] Pacific lamprey, and resident fish species including white sturgeon and ESA listed bull trout. The lower Snake River also used to support a dynamic upland ecosystem that included 48 islands, and many deer, upland game birds, and other furbearers and non-game species that is now submerged under the reservoirs.

The dams' impact to salmon runs was predicted in advance by tribes and others. In a report from the U.S. Fish and Wildlife Service to the Army Corps on a study initiated in 1944, USFWS said: "The lower Snake River dams present, collectively, the greatest threat to the maintenance of the Columbia River salmon population of any Project heretofore constructed or authorized in the Basin. Because of this, serious doubts have been raised as to the possibility of maintaining anadromous fish populations in the Snake River watershed."[38] After the LSRD were constructed the number of salmon dropped significantly. Naturally produced salmon and steelhead have declined significantly compared to pre-dam abundances which were already a fraction of their historic abundance; the current naturally produced abundance of spring/summer Chinook is only 31% of the abundance in the 1950s and the current abundance of steelhead is only 24% of the abundance in the 1960s.[1110] The Snake River Basin used to support about 50% of the Chinook salmon and steelhead in the entire Columbia River Basin.[35]

Significant investments in hatchery production, habitat protection and restoration in areas that remain accessible, and improvements to fish passage have been made since the dams were put in place and continue today. Despite these efforts, wild salmon continue to decline. Many runs of Snake River salmon and steelhead are rapidly reaching the Quasi-Extinction Threshold (QET), or the point at which population levels are so low that the population is uncertain to persist, and the probability of recovery is low without substantial intervention. Currently, 42% of the Snake River spring/summer Chinook populations have natural origin spawner abundances at or below QET, which is set at 50 spawners. For Snake River steelhead, 19% of populations are at or below QET.[5] It is expected that more populations will be reduced to below QET levels in a few years if no significant action is taken to improve survival. The smolt-to-adult ratio (SARs), or measure of survival, for Snake River wild spring/summer Chinook has decreased by 75% from pre-dam levels. Table 5 illustrates current and historic Snake River salmon abundance, and percentage of populations at or below QET.

Table 5: Current and historic wild Snake River salmon abundance and percentage of populations at or below QET.[6]

Snake River Stock	Current Abundance*	Historic Abundance	Percentage of Populations at or Below QET
Spring/Summer Chinook	7013	1,000,000	42% of populations
Fall Chinook	9207	500,000	
Coho	100	200,000	Extirpated-reintroduced
Sockeye	46	84,000	Dependent on conservation hatchery
Summer steelhead	18,689	600,000	19% of populations

**Current abundance is the average abundance of wild Snake River salmon from 2009 through 2019.*

Over the last two years, returns of some Snake River salmon and steelhead populations have increased compared to extreme low returns of the previous five years, but are a fraction of historic levels and far below goals of the NOAA Columbia Basin Partnership Task Force, a diverse set of stakeholders and tribes. For example, predicted 2022 spring/summer Chinook wild returns are 16,743 which is approximately half of the 33,500 low end goal, a third of the medium goal of 98,750 and only 1.6% of the historic abundance levels.[39] Data shows that recent returns of several salmon populations are declining at rates not seen since the mid-1990s when these species were first listed under the ESA. Some of these declines are so significant, they triggered both the 'Early Warning Indicator' and 'Significant Decline Trigger' indicators established in NOAA's Adaptive Management Implementation Plans, components of the 2016 Biological Opinion that recommended management actions to benefit salmon species.[40] Additionally, NOAA scientists have concluded that "extreme weather events may become the new normal due to anthropogenic climate change with catastrophic consequences for endangered species."[41]

Climate change generally exacerbates threats and limiting factors, including those currently impairing salmon and steelhead survival and productivity. The importance of improving the condition of, access to, and survival to and from the last best high elevation spawning and nursery habitats is accentuated because these habitats are the most likely to retain remanent snowpacks under predicted climate change.[6] Recent findings from a peer-reviewed study on the recovery of salmon in the lower Snake River concluded that breaching is most likely the only way to rehabilitate river habitat and restore aquatic species that are near extinction.[35] A recent draft NOAA report found "the increasing role of deteriorating ocean or freshwater conditions from climate change on the health of salmon and steelhead stocks does not diminish the importance or necessity of taking meaningful actions in areas society has more direct influence over. In fact, the importance and necessity of meaningful actions is heightened, not diminished because of the impacts of climate change."[6] Breaching the LSRD represents an action that is within societal control, supports climate resilience, and can have a profound impact on habitat availability and, in turn, salmon abundance.

While a considerable portion of the Pacific Northwest salmon and fisheries scientific community believe that breaching the LSRD is necessary to restore salmon abundances to achieve regional salmon recovery goals,[42] there are some scientists, e.g., Welch et al. 2021, that do not believe breaching will provide substantial benefits to salmon species, referencing the current survival rates through each of the four dams, i.e., greater than 96%, which is comparable to survival rates for salmon on un-dammed rivers.[43] Welch et al. believes that breaching the LSRD will not result in significant improvements to SARs and there is little evidence of dam-induced delayed mortality in Snake River salmon, that there is limited potential for population-level improvement using freshwater habitat restoration, and that ocean survival is the main driver of salmon mortality.[43] However, in a review of Welch et al.'s research by the Independent Science Advisory Board (ISAB), the ISAB found the paper's conclusions were "speculation and not directly supported (or refuted) by the analysis reported" in their findings.[44] Additionally, the most recent findings from NOAA cite other recent dam breaching projects that have resulted in "broader and quicker biological and physical benefits" than expected to local and regional riverscapes across the west as a source of confidence in the benefits of breaching the LSRD. The report then urges that "uncertainty surrounding the exact magnitude of beneficial response of acting does not warrant inaction."[6]

Unique effects of LSRD to salmon

Salmon have a complex lifecycle and a migration pattern that includes moving long distances through freshwater systems as juveniles, spending several years in the ocean, and returning to natal freshwater streams as adults to spawn. This subjects them to a variety of threats in the freshwater system, including loss and degradation of habitat in rivers and tributaries, destruction of estuary habitat used for rearing, altered habitat and related challenges posed by dams and reservoirs like increased water temperatures and predators, decreased stream velocity and dam passage related mortality, and other human-related threats such as timber harvest, farming, industrial facilities, and urbanization. All of these threats likely have contributed to the decline of salmon runs in the Snake River. While the LSRD are not the sole cause of the decline of Snake River salmon, they have played a significant role. The hydrosystem impacts, both direct and indirect, are the largest source of mortality for Snake River salmon and steelhead, representing a 62% to 80% reduction in natural production.[45] Although the smolt survival rate through each dam is approximately 96%, the cumulative survival rate for Snake River spring/summer Chinook salmon after going through all eight dams along the Columbia and Snake Rivers is estimated to be 64%, translating to a 36% loss. As a result, the LSRD have led to between 8.4 million and 14.3 million pounds of lost tribal harvest annually.[10]

Figure 1 shows current smolt-to-adult return (SAR) rates in the Columbia River Basin for wild spring or spring/summer Chinook salmon. Currently, the SAR goals for ESA listed salmon populations by the NWPCC are set at 2% to 6% with an average of 4%.[46] However, decades of SARs well below 4% for Snake River salmon and steelhead have led to low abundances.[47] Over the last 20 years, spring/summer Chinook have averaged less than 1% SARs and steelhead have averaged less than 2% leading to generational declines in abundance.[35] These low SAR levels are not found in nearby tributaries downstream from the LSRD. A comparison of salmon survival between two rivers is illustrative of the impacts the LSRD have on spring/summer Chinook SARs. Spring Chinook from the John Day River, a tributary to the Columbia River, have a SAR of 3.5% while spring Chinook populations from the Grande Ronde, a tributary to the Snake River, have a much lower SAR of 0.8%.[48] The two river systems have similar watershed characteristics, with the only significant difference being that Snake River salmon have to navigate eight dams to and from the ocean, while John Day salmon navigate only three.

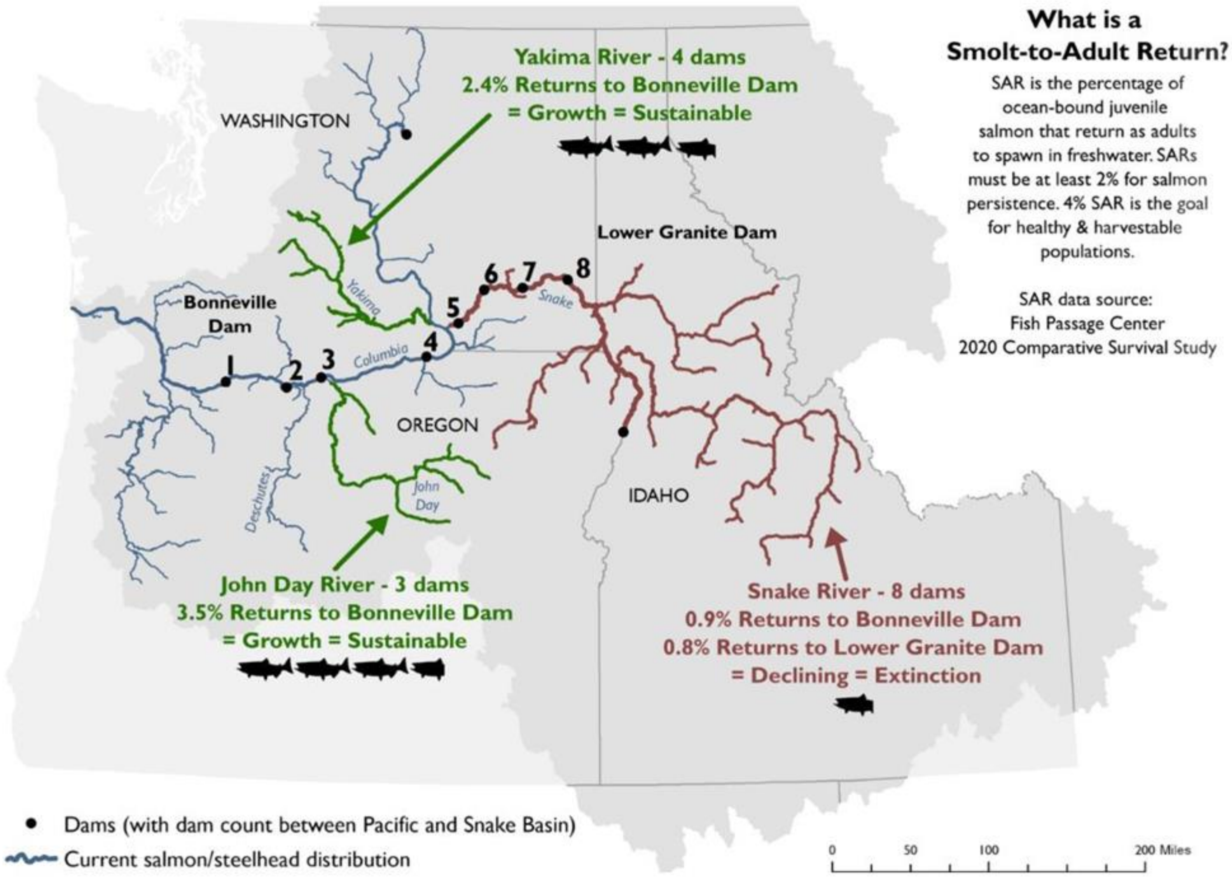

Figure 1: Wild Chinook salmon SAR returns in the Columbia River Basin.[48]

If the LSRD remain in place, the current and future operations of the Columbia River hydroelectric system will need to be carefully balanced to meet the needs of salmon through actions like spill, which could come into conflict with the energy flexibility needs of the region. Future projections in dam operations at Dalles Dam further downstream on the Columbia River predict large daily swings in release of water ranging from 100,000 and 400,000 cubic feet per second.[5] BPA does not see this as a realistic operation of the Columbia River system due to operational constraints. The Columbia River Inter-Tribal Fish Commission's Energy Vision for the Columbia River Basin warns that, "This would be a radical operational change, with implications for water temperature increases, delayed adult salmon migration, treaty fisheries, and spill operations at other lower Columbia River dams."[5] Daily fluctuations change river water levels, and juvenile fish that feed and live near the shore can be stranded and die when water levels are reduced. Migration of fish is interrupted when flows decrease at night because there is less demand for electricity and therefore less water moving through the reservoirs behind the dams. The report also states that, "the water held behind storage dams for power generation would, under natural conditions, be in the river aiding the swift and timely downstream migration of young salmon. Saving this water for winter and summer energy production alters the natural (or normative) river conditions that aid juvenile salmon migration and would help in the restoration of fish to harvestable levels."[5]

Broad consensus for salmon recovery goals

The NOAA Columbia Basin Partnership Task Force (2017 – 2020) was a collaboration of different interests from across the Columbia River Basin including environmental, fishing, agricultural, utility, and river-user groups, local recovery groups, the states of Idaho, Montana, Washington and Oregon, and federally recognized tribes. One of the key findings of the Task Force was "the status quo is unacceptable: without significant change, imperiled salmon and steelhead will disappear forever."[45] This diverse group of leaders across the region agreed on a set of goals for each of the 27 salmon stocks in the Columbia River Basin, including the Snake River salmon stocks. This was the first time any group has reached consensus on a comprehensive set of goals for salmon recovery, and these goals went beyond just meeting ESA requirements. Near-term goals called for achieving healthy, harvestable levels of salmon and long-term goals anticipated restored ecological function of the watersheds in the Columbia Basin. An overarching message from the Task Force is that immediate action is urgently needed to address salmon and steelhead declines in the Columbia River Basin.

This was not the first effort to establish basin-wide salmon recovery goals to reverse the declining salmon abundances that have been observed in the Columbia Basin. The region has come together to develop multiple salmon recovery goals over the years. In 1987 the NWPCC set an interim goal of doubling salmon and steelhead runs from 2.5 million to 5 million adult fish. In establishing this interim goal, the NWPCC conducted comprehensive research to determine annual adult salmon and steelhead run sizes prior to major development in the Northwest and determine salmon and steelhead losses due to the hydrosystem. At that time, the NWPCC warned that, "meeting the Council's interim goal of doubling the runs will depend on the resolution of conflicts among production, passage, and harvest. An accommodation between the desire to substantially increase runs and the need to protect wild and natural runs must be reached." These goals were not met and five years later, Snake River spring/summer Chinook were listed under the Endangered Species Act. In 1995, the Nez Perce, Umatilla, Warm Springs, and Yakama tribes developed their salmon restoration plan, Wy-Kan-Ush-Mi Wa-Kish-Wit, Spirit of the Salmon.[49] The plan's vision is to put fish back in the rivers and protect the watersheds where fish live. The plan was created in response to the precipitous decline of salmon in the Columbia River Basin from their estimated pre-contact numbers of 15 million to 20 million fish annually to fewer than 500,000 in the late 1970s. The plan's goal is consistent with both the NWPCC and the NOAA Columbia Basin Task Force goals. However, the problem with salmon recovery in the Columba Basin has not been the lack of adequate assessment and planning. Rather, the reason experts believe the region is not achieving recovery and rebuilding is a lack of federal funding for an adequate suite of actions to achieve success.

NOAA recently identified Snake River spring/summer Chinook and steelhead as two of the five highest priority Columbia Basin salmon stocks for protection and rebuilding. The prioritization of stocks was based on multiple factors, including level of extinction risk, importance to tribal communities, and resilience of habitat to climate change. The 2022 draft NOAA report found that breaching the LSRD is essential to include as part of a comprehensive suite of management actions to reach the mid-level goals agreed upon by the Columbia Basin Partnership by 2050 and the NWPCC SAR goals by 2030. Both the Columbia Basin Partnership and this recent NOAA report identified the importance of maintaining and restoring access to high-elevation spawning and rearing habitat in the upper Snake River as a means to buffer species from the effects of climate change.

Given marine-associated mortality is expected to increase over time due to climate change, reducing freshwater stressors is essential to increase resilience.

The following graphs show the abundance levels of natural-origin Snake River spring/summer Chinook, steelhead, and sockeye since LSRD construction began in comparison to the recent 2020 Columbia Basin Partnership abundance goals. There is a noticeable decline during construction of the LSRD in the 1950s and 1970s, followed by further decline and low abundances in the 1990s to present day. As figure 2, figure 3, and figure 4 illustrate, salmon abundances across all populations have been below the abundance goals that were laid out by the Columbia Basin Partnership. Fisheries experts indicate that the spikes in abundance in some years since 2001 were due to favorable ocean conditions and, in some years, favorable freshwater out-migration conditions (Idaho Conservation League, pers. comm., April 22, 2022; Oregon Department of Fish and Wildlife, pers. comm., February 15, 2022). Fisheries experts note that favorable ocean conditions and water years are expected to become less frequent in the future due to climate change, emphasizing the need to alleviate other stressors in their life cycle to help salmon populations remain viable when conditions are not ideal.

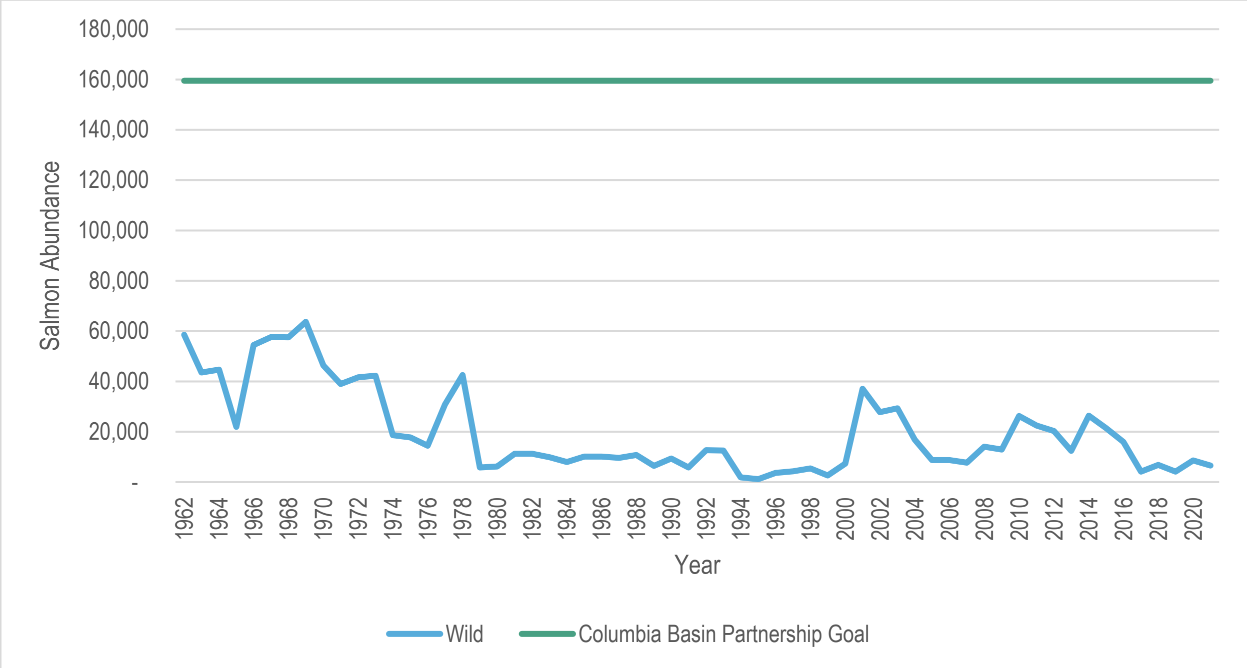

Figure 2: Abundance of Snake River wild spring/summer Chinook from 1962 to 2021 (Source: Idaho Conservation League).

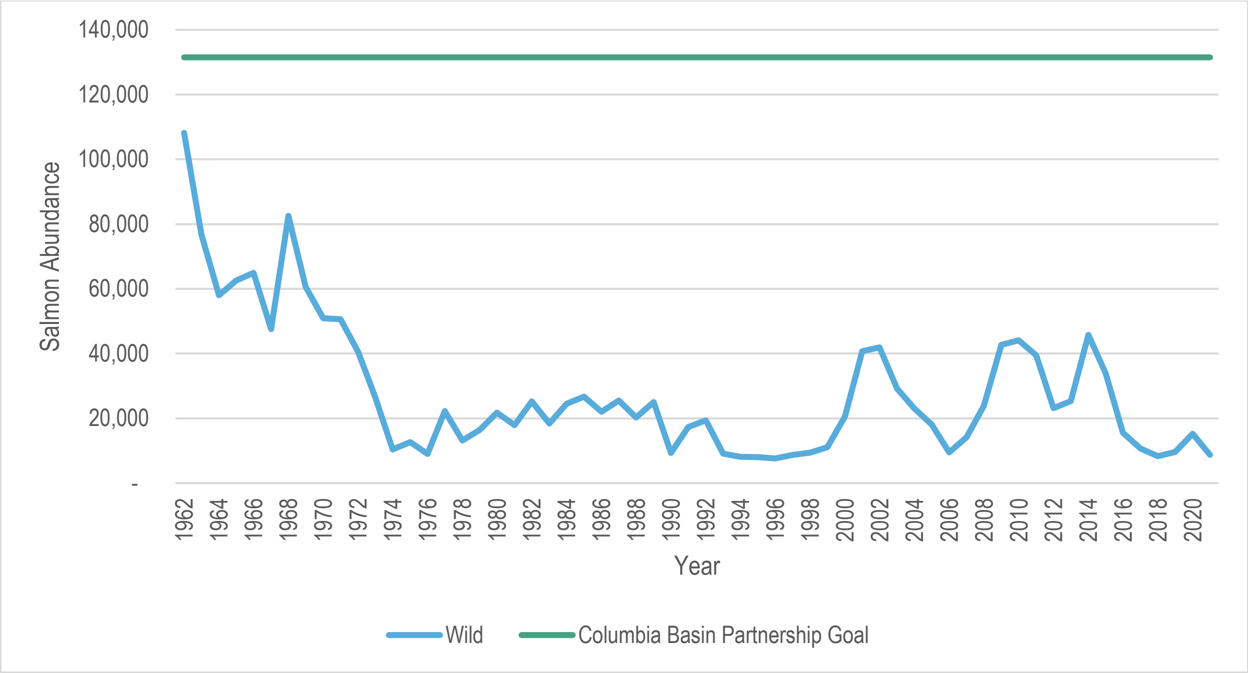

Figure 3:Abundance of Snake River wild steelhead from 1962 – 2021 (Source: Idaho Conservation League).

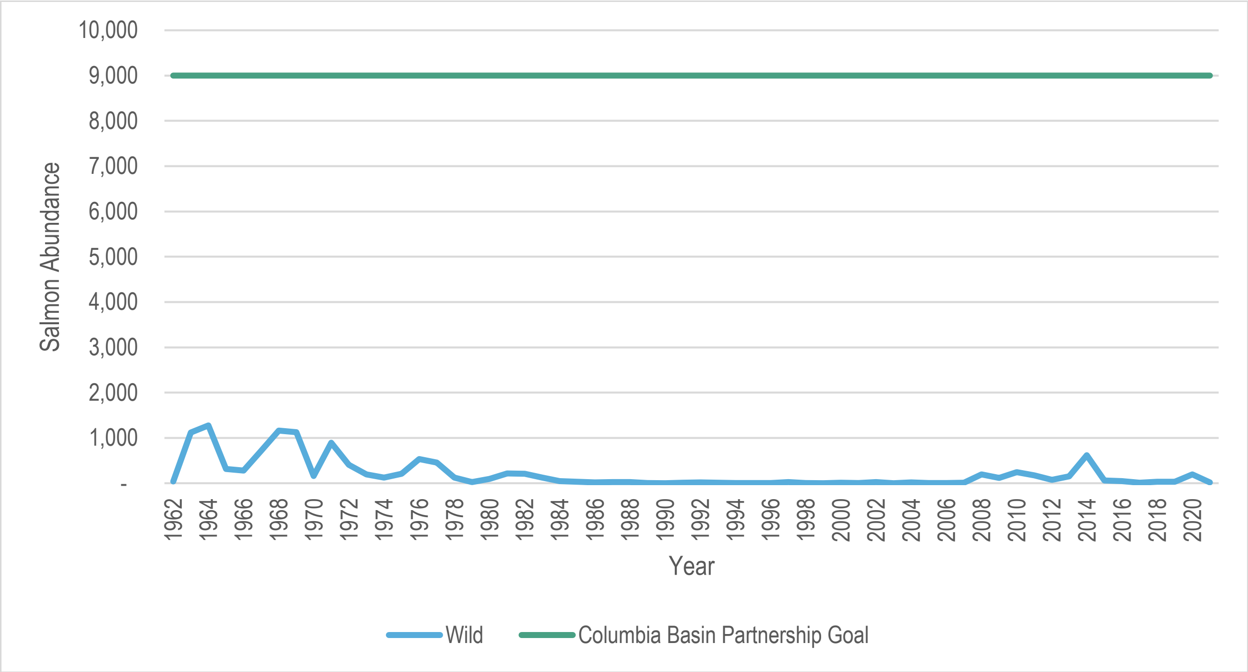

Figure 4: Abundance of Snake River wild sockeye from 1962 – 2021 (Source: Idaho Conservation League).

Benefits for salmon and other aquatic species

Multiple studies predict long-term benefits of breaching the LSRD for Snake River salmon.[50] Within the 2020 CRSO EIS, dam breaching resulted in the highest predicted potential SAR for Snake River salmon and steelhead of the alternatives evaluated.[9] Both the Comparative Survival Study Model

(CSS) and NOAA National Marine Fisheries Compass Model (LCM) indicate significant long-term benefits for salmon from dam removal. The CSS model predicts that juvenile spring/summer-run Chinook salmon migrating downstream from Lower Granite Dam would return to Lower Granite Dam as adults (SARs) at an increase of 170% and juvenile migration survival rate would increase 10.5% if the LSRD are breached.[7] The NMFS LCM predicts that returning spring/summer-run Chinook salmon adult's juvenile migration rate from Lower Granite Dam to Bonneville Dam would improve by 14% on average, while juvenile migration survival rate would increase 9.12% on average. Snake River fall Chinook and sockeye are also expected to have similar improvements to juvenile mortality due to reductions in reservoir mortality.

The CSS model also predicts similar improvements for Snake River steelhead, with a 25.9% increase in juvenile migration survival and a 3.2% increase in SAR. Juvenile travel time and survival for Snake River sockeye also are predicted to improve. In addition to increased survival, breaching the LSRD is expected to provide a long-term benefit to species, such as fall Chinook, that would spawn and rear in the 140 miles of mainstem Snake River habitat currently inundated. According to the 2020 CRSO EIS, the Snake River is predicted to have a 15-fold increase in spawning habitat from 226 acres to 3,521 acres in the event of breaching.[7] This benefit will take time to fully realize, as it is expected to take two to seven years for the re-establishment of the natural river channel. Additionally, in the years immediately after breaching the increased water velocity should provide an immediate benefit to salmon migrating through the Snake River. Figure 5 shows the anticipated probabilities of improving SARs for spring/summer Chinook and steelhead under each of the alternatives prescribed in the 2020 CRSO EIS. For both species, breaching (MO3) and breaching with additional spill at the lower Columbia Dams (MO34), are projected to have the highest probability of improving SARs above 2% and have the lowest probability of reducing SARs to below 1%.

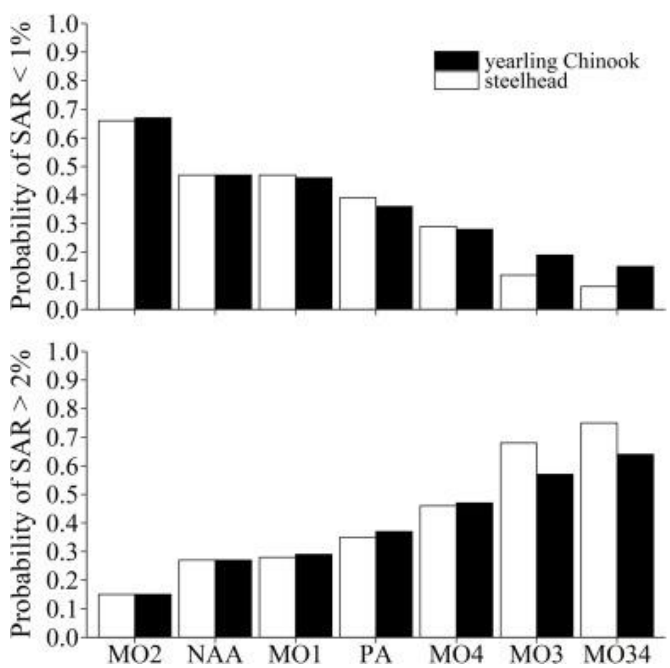

Figure 5: Probabilities of SARs for spring/summer Chinook and steelhead resulting in declining returns (<1% (top)) and stabilizing returns (>2% (bottom)) under the alternatives prescribed in the 2020 CRSO EIS.[7]

Potential breaching of the LSRD is also predicted to improve survival and habitat for non-salmon species. For example, Pacific lamprey are expected to have improved adult in-river passage compared to current conditions on the Snake River, and juvenile lamprey are predicted to have improved in-river survival due to the elimination of potential mortality associated with the dams, for example turbine passage and increased reservoir predation. Potential breaching of the LSRD would directly increase white sturgeon habitat, allowing for viable natural recruitment and continuous connectivity with areas upstream in the Snake and Clearwater Rivers.[6] Bull trout would also benefit from increased connectivity between tributary and mainstem habitat.[6] Historically lamprey and sturgeon contributed significantly to tribal diets and removing the dams would greatly improve population abundance for those species and restore tribal harvest practices.(Yakama Nation, pers. comm., August 1, 2022)

Southern Resident orca are declining due to a combination of three limiting factors: (1) prey availability, (2) vessel noise and disturbance, and (3) toxic contaminants. Although Southern Resident orca consume a variety of fish and one species of squid, salmon are their primary prey, particularly Chinook salmon. Depending on the season, Chinook can account for 50% to 100% of the Southern Resident's diet. In mid-winter/spring, the time corresponding to the Southern Resident's highest use of coastal waters, Chinook salmon can represent 70% to 80% of their diet.[12] Chinook salmon from the Columbia Basin regularly account for more than half of the total salmon consumed by Southern Residents. Recent research indicates that as salmon populations have decreased within the Southern Resident's traditional summer feeding grounds in the Salish Sea, Columbia Basin Chinook salmon has become a large proportion of their annual diet.[13]

The Southern Resident orca have shifted feeding habits and are spending more time foraging for salmon off the west side of Vancouver Island, Canada. As a result, their diets have become more reliant on Columbia Basin Chinook.[51] Early spring Chinook returning to the Snake and Columbia Rivers are large, have a high fat content, and provide additional unique nutritional value to Southern Resident orca in the late winter and early spring.[52, 53] The quality and quantity of Chinook directly influences Southern Resident orca health and nutritional status, and a lack of sufficient prey causes nutritional stress, which has been linked to reductions in growth rates, adult length, and social cohesion.[54] Insufficient prey also directly contributes to increased mortality in the population, which has been correlated with coastwide indices of Chinook abundance.[55] Research assessing the changing nutritional status of Southern Resident orca indicates that the conservation of early spring Chinook runs may be especially important to recovery efforts for the Southern Resident pods.[56, 57]

NOAA has stated, "perhaps the single greatest change in food availability for resident killer whales since the late 1800s has been the decline of salmon in the Columbia River."[14] While there was a small improving trend for Columbia Basin Chinook salmon from very low returns in 2018 to somewhat higher returns in 2020, Southern Resident orca still experienced energy deficits due to lack of prey availability.[13] Increases in overall Chinook salmon abundances, including Snake River Chinook, should help increase prey availability for the Southern Resident orca, but other mitigation measures would be needed to alleviate other stressors.

Dam impacts to tribes and benefits of breaching

Successful salmon recovery is of critical importance to tribes of the Columbia and Snake River Basins and throughout the Pacific Northwest. On the impact of the hydroelectric system on tribal communities, the Affiliated Tribes of Northwest Indians stated, "the modern Northwest with its massive irrigation, hydropower, and storage systems was built on the backs of tribal peoples from the 1930s on, through the use and destruction of the lands, rivers, and fisheries we have lived with for thousands of years and tribal cultures and lifeways are rooted in place and tied to their homelands, but tribes cannot just relocate to access traditional resources."[8] Loss of salmon and other aquatic species contributes to declines in health and wellbeing of tribal people through increased disease, poverty, unemployment, mortality and a fraying social fabric.[10] The reservoirs have inundated tribal cultural sites and affect tribes' ability to carry out cultural rituals and honor ancestors at many places important to them. Tribes - and their natural and cultural resources - have borne the costs for the economic development of the river that has benefited non-tribal industries and non-tribal populations.

Prior to European settlement, tribal people inhabited land throughout the Columbia and Snake River Basins and built thriving cultures and communities based on the abundant salmon and other natural resources in these places. When they gave up land to European settlement, Tribes entered into treaties with the United States Government to reserve rights to maintain access to all the resources and places that sustained them. The "fishing clause" in these treaties guaranteed "the right of taking fish, at all usual and accustomed grounds and stations . . . in common with all citizens of the Territory." Salmon were a central concern. The Supreme Court of the United States has repeatedly recognized the significance of salmon to the tribes and the treaty right to fish at off-reservation usual and accustomed places, holding that the right is "not much less necessary to the existence of the Indians than the atmosphere they breathed."[3] This treaty right to fish is also a property right, protected by the Fifth Amendment to the Constitution of the United States.[58] The treaty fishing right carries with it an inherent right to protect the resource from human caused impacts. "[A] fundamental prerequisite to exercising the right to take fish is the existence of fish to be taken."[2,3] The ecosystem necessary to sustain the fish cannot be diminished, degraded or contaminated such that either the fish cannot survive, or that consuming the fish threatens human health.[*]

There is also a unique fiduciary relationship between the United States government and Indian tribes. This unique relationship establishes the government's responsibility, in carrying out its fiduciary duties, to "ensure that Indian treaty rights are given full effect." This means government agencies and departments have a responsibility to protect the tribes' treaty fishing rights in making operational decisions.[59]

---

[*] United States v. Washington, 2013 U.S. Dist. LEXIS 48850, 75 (W.D. Wash. Mar. 29, 2013) aff'd, 853 F.3d 946 (9th Cir. 2017) aff'd per curiam, 138 S.Ct. 1832 (2018) (State "impermissibly infringed" tribes' treaty-based fishing right in Washington by constructing culverts that "reduced the quantity of quality salmon habitat, prevented access to spawning ground, reduced salmon production…and diminished the number of salmon available for harvest.") See also, e.g., Kittitas Reclamation District v. Sunnyside Valley Irrigation District,763 F.2d 1032, 1034-35 (9th Cir. 1985) (Tribe's fishing right can be protected by enjoining ground water withdrawals that would destroy eggs before they could hatch).

Beginning almost immediately and continuing to today, tribes' ability to access their treaty-reserved rights has been limited. This has come about through direct removal of land from tribal control, dramatic reduction in the overall abundance and availability of salmon and other resources, alteration of the landscape in ways that cuts off tribal access to harvest locations and prevents religious ceremonies at their traditional places, and suppression of tribal culture. The Nez Perce, for example, have lost 78% of the land reserved for themselves in their original treaties and in many cases, lost the highest valued lands within reservation boundaries. The Nez Perce Tribe alone historically occupied approximately 13 million acres and utilized an area much larger stretching from present day Montana and Wyoming to the tributaries of the Columbia and Snake Rivers (Figure 6).[60,61]

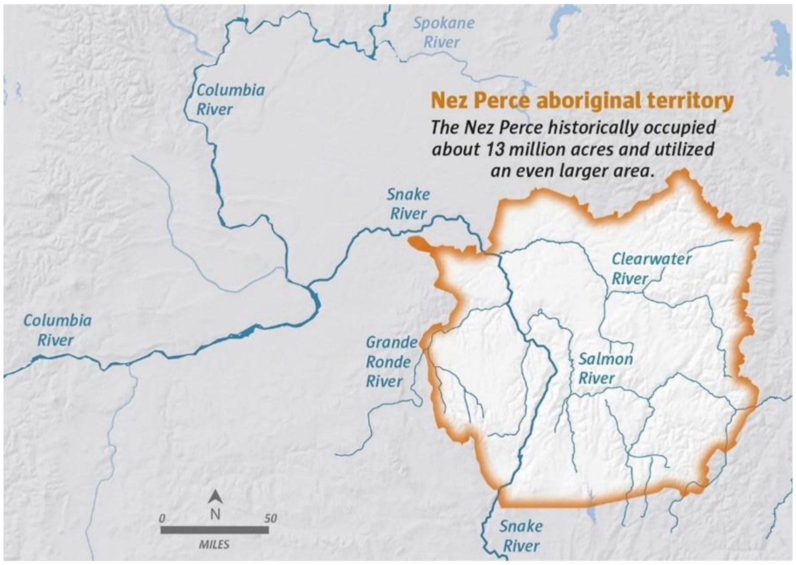

Figure 6: The Nez Perce Tribe alone occupied about 13 million acres of land and used an area from present day Montana and Wyoming to the tributaries of the Columbia and Snake rivers in present day Idaho, Washington, and Oregon.[60]

Yakama Nation has fishing rights on the lower Snake River, and the state of the Snake River fisheries impacts all four of the Lower River Treaty Tribes (LRTTs) with Treaty fishing rights in Zone 6, an exclusive treaty Indian commercial fishing area, of the Columbia River. The lower Snake River falls within the Yakama Nation's usual and accustomed fishing, hunting and gathering areas. The Yakama Nation's ceded lands run along the north shore of the lower Snake River. Tribal members continue to practice their treaty rights along the shore and within the lower Snake River and its tributaries today. Hundreds of cultural sites lie beneath the reservoirs created by the Snake River dams.

Construction of the LSRDs resulted in the loss of ancestral use, e.g., fishing, hunting, and gathering, sites, legendary sites, village sites, monumental sites, ceremonial sites, petroglyph/pictograph sites and archaeological sites, all which the Yakama Nation considers sacred. At many of these sites, the federal agencies have not actually implemented any mitigation measures. Moreover, there are a significant number of sites along the Columbia River that the federal agencies have yet to formally analyze. As a part of the Columbia Basin Partnership, representatives from the Columbia River Treaty Tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated, and Tribes and Bands of the Yakama Nation) asserted that the status quo in the region should not be normalized and that tribal nations will not concede their long-standing tribal goals for salmon and steelhead restoration, which places the baseline for restoration and harvest at 1855 levels when treaties were first signed.

That tribal harvest entitlement is not a 'new' action that incrementally increases the survival gaps of diminished Columbia and Snake River runs, but rather as a baseline that the fish runs have always encountered and that the United States secured by treaty to the tribes.[45] In finding a path forward the Columbia River Treaty Tribes stated, "We are asking too much of Columbia River salmon. The salmon are telling us this. There is no other river for these fish and there is no alternative water to bring to it. The opportunity and challenge for us going forward is whether the region can socially and economically innovate for the salmon."[45]

The Affiliated Tribes of Northwest Indians and National Congress of American Indians have recently called for bold action from Congress and the White House to address ecological and environmental justice issues in the Snake River Basin.[7,62] Calls to action for salmon and steelhead restoration include breaching the LSRD, optimizing spill to benefit salmon at the mainstem federal Columbia River Dams, restoring salmon behind blocked areas in the upper Columbia and upper Snake Basins, and ensuring that tribes and state co-managers become responsible for implementing salmon restoration.[62] The authors noted that solutions must "invest in a stronger, better Northwest that goes beyond salmon, ensuring that communities impacted by river restoration are made whole – and in doing so offering additional opportunities for Tribes within other sectors – from infrastructure and technology development to energy production."[62]

Recent Nation-to-Nation convening between the White House's Council of Environmental Quality and Tribes of the Columbia River Basin in March 2022 acknowledged "that the expertise and sovereignty of the Tribes should be recognized in federal agency processes and actions that might affect the Basin" and that "this is a priority of the current Administration."[63] These discussions further stressed the pressing need of salmon restoration and that, "for the Tribes, their past, present, and future is inextricably linked to the continued existence of salmon and the health of the rivers that support them, which is why the Tribes experience profound consequences from the dwindling salmon runs."[63]

The White House's Council of Environmental Quality convened an intergovernmental agency group consisting of members from the Department of the Interior, including the Bureau of Indian Affairs, Bureau of Reclamation, US Fish and Wildlife Service, NOAA, the Department of the Army, including the Army Corps, and the Department of Energy, including BPA to, "build on existing analyses to identify a durable path forward that ensures a clean energy future, supports local and regional economies, and restores ecosystem function, while honoring longstanding commitments to Tribal Nations."[63] These discussions also stressed the need that a solution must "account for the varied and crucial services provided by the dams, as well as the people, communities, and industries who rely upon them. We cannot continue business as usual. Doing the right thing for salmon, Tribal Nations, and communities can bring us together. It is time for effective, creative solutions."[63]

NOAA & Comparative Survival Study models show that breaching the dams significantly improves the passage for salmon, steelhead and lamprey.[9] According to analysis by the Plan for Analyzing and Testing Hypotheses (PATH) and its Scientific Review Panel, a scenario in which the dams were breached would have the highest likelihood of removing salmon from ESA listing and maintaining treaty and trust obligations within 48 years as compared to other alternatives. In turn, this increase in salmon abundance would increase tribal harvest by 29% annually.[5] Though removal from ESA listing is a desired goal of Washington state, the tribes support a goal of increasing salmon abundance by four to five times the ESA delisting requirement in line with the Columbia Basin Partnership and NWPCC goals.

Breaching the dams would permanently drain the four lower Snake River reservoirs and create substantial benefits for affected tribes. It would allow tribal peoples to renew their close religious and spiritual connection with approximately 34,000 acres of land where their ancestors lived and are buried - and allow them to properly care for their grave sites. They could return to more than 600 to 700 locations where they were accustomed to live, fish, and hunt; harvest plants, roots and berries, conduct cultural and religious ceremonies, and pursue other aspects of their normal traditional lives.[10] Restoration of salmon abundance levels would also greatly benefit tribal fisheries, both commercial and subsistence, which are important for providing livelihoods to tribal members in an occupation that aligns with their preferred lifestyle.[10] Salmon and steelhead is the primary food source for Columbia Basin tribes today, and has been for thousands of years, with many consuming fish at rates higher than non-native populations.

Dam impacts to recreational and commercial fisheries and benefits of breaching

Columbia River salmon and steelhead support long-standing and valuable recreational, commercial, and subsistence fisheries throughout the Columbia Basin and along the Pacific coast. Within the Columbia Basin, recreational fishing is a major economic driver of rural communities. Economic benefits are shared across communities, from fishing guides to small bait-and-tackle store owners, boat dealers to local hotel proprietors, authors of printed fishing guides to local restaurants, and charter boat operators to outfitters.[11] Recreational catch and associated trips and expenditures tend to be highest in the lower Columbia River and next highest in the lower Snake River where steelhead is the primary target species. Recreational trip expenditures in the lower Snake River contributed to $33 million[AL] in personal income and 922 jobs in the Columbia River basin.[11] Saltwater recreational salmon fisheries in Washington generated $90 million[AN] in personal income and 1,783 jobs, and $30 million[AO] in personal income and 715 jobs in Oregon.[64] Further inland in Idaho, in 2020 despite low salmon and steelhead returns, the Idaho Department of Labor estimates that steelhead fishing alone brings in approximately over $8.6 million per month into Clearwater and Nez Perce Counties, with a significant portion of that economic activity coming from outfitted services.[65] It has been estimated that restored salmon fisheries in the Columbia Basin could generate up to $1 billion[AP] annually in additional regional personal income benefits and support up to 25,000 new family wage jobs.[11]

For ocean fisheries, about 32% of the Chinook salmon in non-tribal commercial fisheries along the Washington and Oregon coasts consist of Columbia River stocks. Further north in Alaska and British Columbia, Columbia River Chinook salmon consist of 28% and 8% of the Chinook harvested respectively.[11] The ocean salmon troll fishery sector is composed of relatively small boats usually employing only one to three crew members.[11] Traditionally, salmon were a pillar of ocean commercial fisheries, but due to declines in abundance many trollers must now harvest a variety of other species like crab, tuna, and halibut in order to survive. Columbia River mainstem commercial gillnet fisheries have experienced significant reductions since the construction of the federal hydro-system, with additional fishing closures enacted each decade since the 1950s in response to salmon population declines. The current Columbia River commercial fisheries are limited to off-channel sites and a few days in the mainstem Columbia in areas and times where fisheries can focus on hatchery fish and the few remaining healthy and harvestable naturally produced stocks. The restoration of Columbia Basin salmon has the potential to be an opportunity for the ocean salmon troll and Columbia River commercial fisheries to regain stability as both an industry and as an important local food production system. In addition to the direct benefits of the Pacific salmon fishery, additional jobs are indirectly generated by the salmon fishing industry and occur in smaller coastal communities whose economies are heavily dependent on the fishery. For example, the Astoria, Oregon, and Ilwaco, Washington port areas were important salmon processing centers, and declining harvests in the Columbia River commercial fishery have led to major declines in these industries.[11] Today there are barely 100 Washington-based salmon trollers, representing a loss of approximately 6,000 jobs in the fishing fleet and more in onshore businesses that provide services, supplies and equipment to the fleet. The value of fish landed by these trollers declined from an average of $31.4 million annually from 1976 to 1980 to $2.75 million from 2014 to 2018. From 2010 to 2018, the Pacific commercial salmon fishery landings indicated decreased harvest ranging from 64% to 41%. As a result, revenues fluctuated, with salmon revenues decreasing between 41% and 25%.[64]

Treaty fisheries in Zone 6, an exclusive treaty Indian commercial fishing area, of the Columbia River have been severely reduced and restricted to protect ESA listed fish returning to the Snake River for decades, resulting in unequal economic burden to all the Lower River Treaty Tribes. The tribes have shouldered the conservation burden created by the hydro system. The degradation of this resource is linked to increased poverty and unemployment in tribal communities. An example of the unfair placement of burden on the tribes is the 2022 year's upper Columbia sockeye and summer Chinook returns. While these salmon returns are at near record levels for the recent past, strict regulations were imposed on tribal fishers that limited their upper Columbia sockeye catch to avoid incidental harvest of Snake River sockeye salmon. In addition, once a certain portion of sockeye salmon, from any origin, are captured annually, summer Chinook fishing is also closed. Since Snake River sockeye migrate at the same time as upper Columbia fish, tribal fishing seasons are severely limited because of the ESA listed status of Snake River stocks. Although the quantification of this type of impact to the tribes is difficult, lost fishing opportunities result in innumerable lost religious, subsistence, and economic benefits to the tribes.

While the overall trend of commercial salmon and steelhead harvest has been downward since the 1930s, the losses of these economic contributions can be recaptured if efforts to improve abundance, to levels like those laid out in the Columbia Basin Partnership, are successful. Restoring salmon and steelhead will not only benefit small rural communities, both along the coast and within the inland Columbia Basin economically, but also their generational relationship with salmon.

5. Navigation and Transportation of Grain and Other Commodities

Overview

The transportation network that serves the region surrounding the LSRD includes rail lines, barges and trucks. While all parts of the transportation network would be affected if the LSRD were to be breached, barge transportation would be most impacted. Barge transportation currently extends to Lewiston, Idaho. Breaching would eliminate barge transport above the confluence of the Columbia and Snake rivers near Pasco, Washington.

The predominant commodity shipped by barge within the transportation network is wheat. Wheat producers use trucks to send their product to storage facilities near the growing areas. From there wheat is loaded onto barges or railcars destined for exporters on the lower Columbia River. Washington-grown (or processed) wheat was the second most valuable Washington state agricultural export in 2021, with a value of $1.0 billion[AS].[66] In 2020, the Columbia River ports exported approximately 16 million short tons of wheat, of which three million short tons was shipped on the Snake River and just under two million was shipped on the Columbia River, below the Snake River.[67] Data for rail shipments of wheat to the Columbia River ports, some of which is produced in Montana and North and South Dakota, are not publicly available. However, the volume of wheat shipped by rail can be estimated by subtracting the barged volume (five million tons) and the exported volume (16 million tons). By this method of estimation, approximately 11 million tons of wheat was shipped by rail to Columbia River ports in 2020 and over 80% of the wheat exported from lower Columbia River facilities did not use the LSRD.

Although representing a smaller proportion than wheat by weight and volume, other commodities such as chemicals, forest products, fertilizers, and iron scrap also rely on barging up and down the Columbia and Snake River systems. The LSRD also help support four cruise ship lines which are discussed in Section 8: Recreation and Tourism.

The barging system provides a reliable and cost-effective shipping method. Breaching the LSRD would eliminate barging between the Port of Lewiston and the Tri-Cities and would require shifting the transportation mode for barged commodities to rail or truck. Several studies have examined the impacts of breaching the LSRD to transportation cost, reliability, and capacity, as well as public safety, and emissions. Replacing the transportation benefits of the dams requires providing viable transportation alternatives and would include adding new and upgraded rail and road transportation infrastructure which would bring its own associated costs and benefits. Cost estimates for replacing transportation benefits range from $542 million to $4.8 billion (see Table 9). This wide range is driven by different assumptions about the extent of transportation infrastructure development and upgrades that would be needed, the cost of increased air pollutant emissions and road accidents, and the level of compensation provided to impacted producers, shippers, and ports. Washington Department of Transportation (WSDOT) has stated that a transportation impact analysis is needed to provide a more precise estimate for the rail and roadway improvements needed to replace barge transportation.

Existing LSRD services

From 2002 to 2020 an average of approximately 4.2 million short tons of commodities were transported annually on the lower Snake River between Lewiston and the confluence with the Columbia River.[67] This includes both upriver and downriver traffic. Downriver shipments were primarily wheat, while upriver shipments were primarily fuel and other petroleum products, chemicals, and fertilizers. Fuel and petroleum products have not been transported through Ice Harbor Dam since 2011, and instead terminate at a fuel facility at the Port of Pasco on the Snake River. However, USACE reporting system includes these as lower Snake River shipments. Wood chips and sawdust are mostly barged upriver to supply the Clearwater Mill in Lewiston. The 2020 CRSO EIS notes that, although used infrequently, the barge system also provides a water route for oversized cargo destined for the interior U.S.

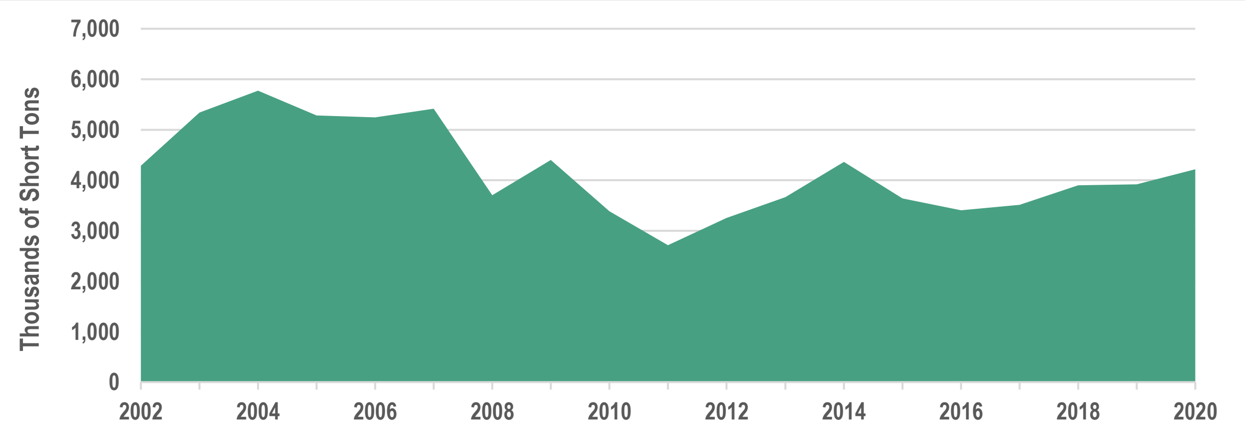

Figure 7: Barged Snake River freight volume for all commodities from 2002-2020 for WA, OR, and ID.[67]

Approximately 90% of wheat grown in Eastern Oregon, Northern Idaho, and Southeastern Washington is moved by barge through the Columbia River barging system. This includes transport through the lower Snake River as well as wheat loaded on barges below the LSRD to move through the Columbia River only. From 2000 to 2020, on average 37% of the wheat exported from the Pacific Northwest moved by barge through the Columbia River and 22% was shipped on the lower Snake River.[67] Need for transportation of agricultural products fluctuates by season, with fall harvest as the highest demand time of year.

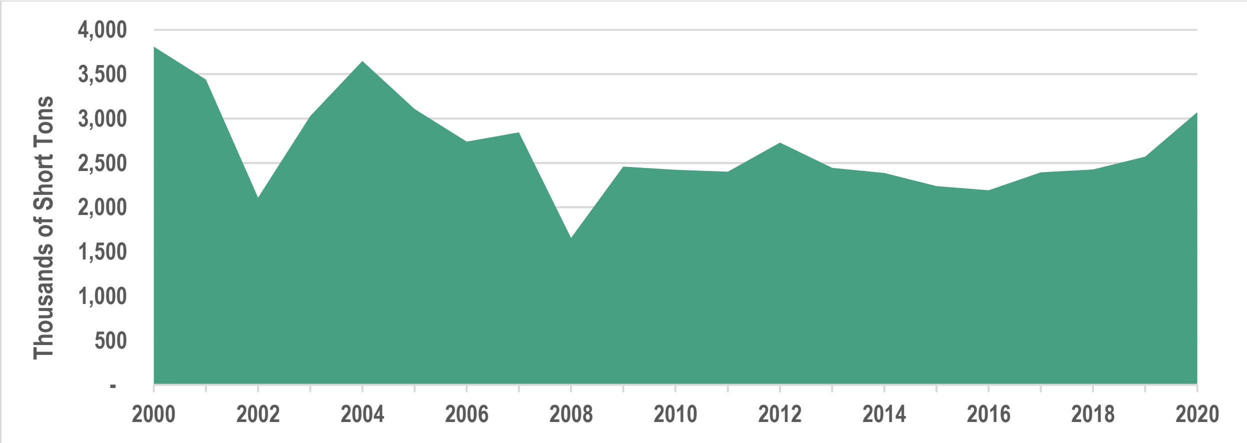

Figure 8: Barged downstream Snake River wheat volume from 2000 – 2020 for WA, OR, and ID.[67]

The cost of shipping wheat and other commodities by barge is subsidized in part by federal tax dollars because the federal government pays for annual operation and maintenance, and capital costs, of the LSRD and associated lock systems. The 2020 CRSO EIS estimates the annual capital costs of the four LSRD at $37 million[AX] and the operations and maintenance costs at $83 million[AC].[21] Some LSRD funding is provided by a tax on commercial-barge fuel through the Inland Waterways Trust Fund (IWTF). As of 2018, IWTF expenditures comprised 5% to 15% of total Army Corps spending on federal inland waterways.[68]

Wheat producers using the barge system consider it the most reliable and cost-effective shipping option for connecting with global agricultural markets. The ability to align barge shipments with other elements of the supply chain such as lower Columbia ports and offloading infrastructure, storage facilities, and ocean-going cargo vessels is a key component to regional agricultural competitiveness (PNWA, pers. comm., February 27, 2022). Wheat producers note that barge service on the LSRD is highly responsive to increases in demand, with barge operators responding to requests for "just in time" service to grain elevators within one to two days, providing wheat growers with flexibility to adapt to changing customer demand. By contrast, wheat producers report the responsiveness from mainline railroads can be a week or more with a higher level of uncertainty than barge shipping (PNWA, pers. comm., February 27, 2022).

Supported by federal funding that subsidizes the cost of operating the LSRD locks, barging is the lowest-cost option (per ton-mile) for wheat shipping, an additional benefit for Pacific Northwest producers, as they operate on narrow cost margins and use barging to maximize their profit per bushel. In 2019 dollars, the 2020 CRSO EIS used 72 cents per bushel of wheat as an average baseline transportation cost for farmers to move their product to a Pacific Northwest port, with rail rates (also in 2019 dollars) estimated between 50 cents and 75 cents per bushel and barge rates estimated between 30 cents and 45 cents per bushel.[17] If for example a 1,000-acre Washington wheat farm produces 40,000 bushels, the farmer could pay 28 cents per bushel to truck the wheat to the closest river port, and then 40 cents per bushel to barge the wheat to the Port of Portland at a total cost of 68 cents per bushel or $27,200 in transportation costs. The average price of wheat has ranged from $2.70 per bushel in 2000 (2000 dollars) to $7.50 per bushel in 2021 (2021 dollars). In 2020 the average price of wheat was $5.70 per bushel (2020 dollars).[69]

Although wheat is the primary commodity shipped by barge on the LSRD by volume, other products also rely on the barging system. Forest products including sawdust and wood chips are barged upriver from facilities on the Lower Columbia to serve inland pulp and paper mills, most notably the Clearwater Mill in Lewiston. Economic benefits of the Clearwater Mill are discussed in Section 9: Community and Economic Resilience. Fertilizer barged upriver provides an important farm input for thousands of acres of cultivated agriculture, although rail is also used to transport this commodity.

Transportation system impacts

Breaching the LSRD would eliminate all commodity barging between the Tri-Cities and Lewiston-Clarkston causing that transportation to shift to regional rail and trucking networks. Barging would continue to occur between the Tri-Cities and downriver Columbia River ports via the lower Columbia River dams. Removing barging as a shipping option on the lower Snake River will impact shipping costs as well as highway safety, in the form of increased road accidents and fatalities, if not mitigated. Impacts on reliability are also a concern for commodity shippers. Since rail is the next most cost-effective shipping option, stakeholders noted concerns with the ability to move commodities by rail given other demands on the freight rail system. During a recent Surface Transportation Board hearing, Deputy Agriculture Secretary Bronaugh listed several concerns that agricultural stakeholders have with reliability, cost, and quality of rail service. This includes Union Pacific railroad's decision to limit fertilizer shipments as part of a plan to reduce rail system congestion (McGregor Corporation, pers. comm., May 11, 2022).

One of the most significant transportation impacts connected with LSRD breaching is shipping costs. Wheat growers are concerned about increased shipping costs for their products, especially given the low margins associated with wheat production. As mentioned previously, agricultural producers currently enjoy significant transportation cost savings from barging, with lower costs per ton-mile than moving products by rail or truck. Most studies conclude that if barging were eliminated on the lower Snake River, rail would become the predominant regional transportation mode for commodities shipped by barge, with trucking as the next most predominant mode. The impact on rail shipping rates is uncertain. A 2020 USDA-funded study of rail rates for grain shipments found that a variety of factors influence rail rate changes over time, and the analysis suggests that barge competition has decreased in importance as a rail rate pricing factor. The study used national-level data in its analysis.[70]

Several studies analyzed freight costs for products shipped on the lower Snake River using different transportation modes. The FCS study, commissioned by Pacific Northwest Waterways Association (PNWA), estimates transportation and storage costs for wheat will likely increase by 50% to 100% after dam breaching; the study notes that this will require an increase in direct federal farm payments in order to maintain farm operations at current net cash income levels.[71] A 2019 report by ECONorthwest estimated additional annual transportation costs for shippers of $7 million[AZ], which translates into a present value of costs over 50 years of $239 million.[AZ] The 2020 CRSO EIS presents three cost scenarios for removal assuming 0%, 25%, and 50% rail rate increase. The 2020 CRSO EIS concludes that shipping costs, in 2019 dollars, could increase from 7 cents to 24 cents (8 cents to 26 cents in 2022 dollars)[AQ] per bushel (depending on the scenario and the region in which a given wheat producer is located). A 1998 Eastern Washington Intermodal Transportation Study

(EWITS) research report found that the transportation cost per bushel of wheat would increase 1 cent to 6 cents per bushel in 1998 dollars (2 cents to 10 cents in 2022 dollars)[AQ], depending on the scenario.[72] Table 6 summarizes the breakdown of costs to produce and transport wheat to understand the potential effect of increased transportation costs.

Table 6: Comparison of estimated transportation cost increase for wheat in FCS Report, 2020 CRSO EIS, and EWITS.

Source	% Increase	Assumptions
CRSO EIS (2020)	10%	+0% rail rate increase (rail rates remain constant and because rail rates are higher than barge rates, overall transportation costs increase by 10% even with no change in rail rates)
	21%	+25% rail rate increase
	33%	+50% rail rate increase
FCS (2015)	50% - 100%	+50-100% shipping costs based on interviews wheat producers & farm operations managers
EWITS (1998)	2%	+0% rail rate increase; no rail capacity constraints
	10%	+10% rail rate increase; rail capacity constrained
	11%	+20% rail rate increase; rail capacity constrained

Several studies cite shipping prices during scheduled lock outages for maintenance between December 2010 and March 2011 and found that during the outage over 90% of the grain by volume was shipped by rail and that shippers experienced a nearly 40% increase in shipping and storage costs (See: ECONorthwest Report (2019) for example).

Breaching the LSRD also would impact the number of ton-miles shipped by rail and truck, depending on how the system realigns in the absence of lower Snake River barge operations. The FCS study and the 2020 CRSO EIS each estimate increased truck ton-miles and rail ton-miles per year with the removal of the LSRD. The EWITS study also estimates increased truck ton-miles per year with LSRD removal. More recently, a 2022 study by Dr. Miguel Jaller at University of California Davis commissioned by American Rivers and The Water Foundation, uses a similar approach to the CRSO EIS to estimate the changes in truck, rail, and barge ton-miles per year resulting from LSRD breaching.[73] Table 7 summarizes the estimated ton-miles per year changes for transporting wheat under these studies. As the table indicates, the 2020 CRSO EIS and EWITS scenarios assume that producers will increasingly choose to truck their products as rail rates rise because the cost of truck transportation will become more competitive with rail. However, the costs of trucking do not include the cost to producers to purchase and operate additional trucks which may be a significant factor in determining whether to truck or use rail. The 2020 CRSO EIS uses a ten-year average grain shipment of 2.4 million tons downriver to model future shipments, which provides the baseline for the model estimates.[17]

Table 7: Comparison of estimated Increase in truck ton-miles per year from LSRD removal.

Source	% Increase in Truck Ton-Miles/Year	Assumptions
Jaller (2022)	8%	Assignment of flow to mode option is by the cheapest option, with no assumptions about changes in rates
CRSO EIS (2020)	19%	+0% rail rate increase
	32%	+25% rail rate increase
	84%	+50% rail rate increase
FCS (2015)	214%	+50-100% shipping costs (based on interviews with wheat producers & farm operations managers)
EWITS (1998)	15%	+0% rail rate increase; no rail capacity constraints
	61%	+10% rail rate increase; rail capacity constrained
	61%	+20% rail rate increase; rail capacity constrained

Much of the wheat produced in the Snake River region is currently trucked directly from farms to river ports totaling 322,933,030 ton-miles, while a significant amount is trucked from farms to grain elevators with shuttle rail totaling 91,038,006 ton-miles.[17] The 2020 CRSO EIS analyzes the shift in truck, rail, and barge ton-miles under the three rail rate scenarios mentioned above. Under Scenario 1, which assumes no increase in rail rates, rail ton-miles would almost double to 1.5 million from the no action alternative of 818,854 rail ton-miles. Under Scenario 3, which assumes rail rates increase by 20%, rail ton-miles would decrease to 804,188 while truck ton-miles would more than double the no action alternative from 463,957 to 855,422 truck ton-miles as illustrated in Figure 9. Under all the 2020 CRSO EIS scenarios analyzed, truck ton-miles would increase with associated increase in pressure on the existing roadway system. WSDOT notes that additional analysis is required to assess local and state roadway performance, including maintenance and preservation needs. The FCS report, as well as information provided in stakeholder conversations, note that there is currently insufficient availability of commercial truck drivers and that increased demand for trucking would exacerbate this situation. Recent data from American Trucking Association show a nationwide shortage of approximately 80,000 truck drivers in 2021 and a continuation of that trend in 2022.[74] It is unknown if this driver shortage will persist as a significant factor several years into the future to a time period when the dams might actually be breached.

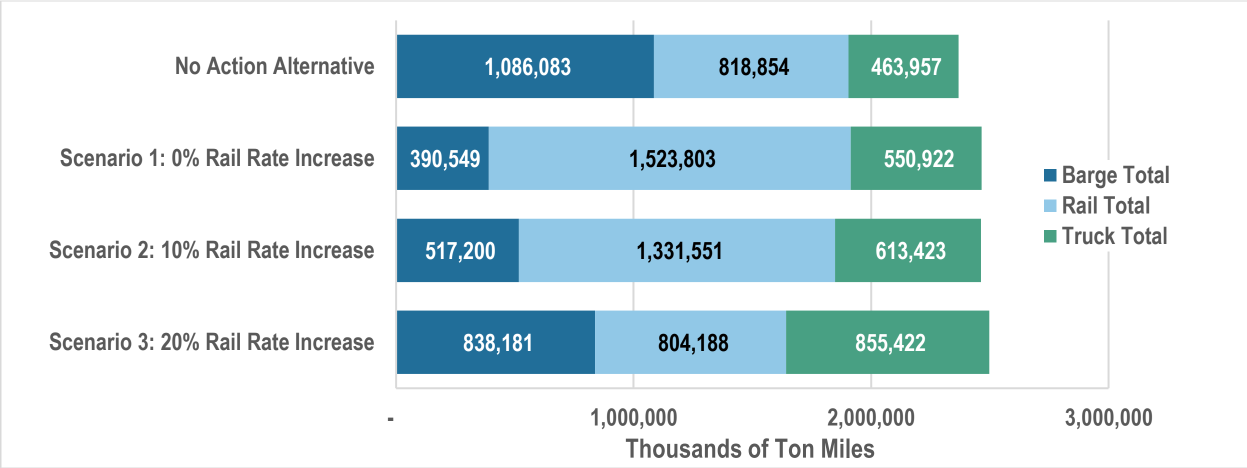

Figure 9: Change in composition of ton-miles under four 2020 CRSO EIS scenarios for wheat currently barged from Port of Lewiston. Note: The No Action Alternative includes barging on the Snake River and Columbia River system and Scenarios 1, 2 and 3 include barging from the Tri-Cities area to the lower Columbia River ports.[17]

Estimated impacts on rail ton-miles in the Jaller study, FCS report and the 2020 CRSO EIS are summarized in Table 8. The EWITS study does not estimate the rail ton-miles increase. The FCS report starts with a baseline of zero rail ton-miles per year to demonstrate the increase that would occur in the absence of barging. The 2020 CRSO EIS estimates approximately 818.9 million rail ton-miles per year as the current baseline. Like trucking, stakeholders commented that availability of grain railcars and grain unit trains is a concern, given competition from other commodities transported via rail.

Table 8: Comparison of estimated changes in rail ton-miles in 2020 CRSO EIS and FCS Report.

Source	Current Rail Ton-Miles/ Year	Estimated Increase	%Δ	Assumptions
Jaller (2022)	679,032,564	625,874,351	92%	(see assumptions in Table 7)
CRSO EIS (2020)	818,854,333	704,949,067	86%	+0% rail rate increase
		512,697,114	63%	+25% rail rate increase
		-14,666,073	-2%	+50% rail rate increase
FCS (2015)	N/A	522,808,000	(from zero)	+50-100% increase in shipping costs based on interviews wheat producers & farm operations managers

Note: The FCS report does not include a baseline of current rail ton-miles per year, it only shows the estimated increase. The 2020 CRSO EIS uses 818,854,33 rail ton-miles/year as the current baseline.

An increase in road and rail ton-miles will affect greenhouse gas (GHG) emissions and road injuries, both of which are estimated by the FCS report, 2020 CRSO EIS and ECONorthwest report. The FCS report estimated the annual change in emissions that would result from dam removal, which under current government guidance is valued at roughly $51 million[I] (or $1.5 billion over 50 years); this current value is much higher than the original estimated value of $7.1 million in the FCS report due to changes in federal estimates of the cost of air emissions, particularly greenhouse gases. Using older data on the per unit cost of emissions[2], the ECONorthwest report describes the net change in emissions costs as $23 million[J] over a 20-year period (this is equivalent to $1.4 million annually or $42 million over a 50-year period at a 2.25% discount rate), noting that the carbon dioxide equivalent, or CO_2e, increase will be the most significant social cost resulting from dam removal. Both reports estimate the costs of carbon emissions based on the social cost of carbon which considers factors such as changes in net agricultural productivity, human health, property damages from increased flood risk and changes in energy system costs associated with climate change. Costs of other types of air emissions are generally based on costs to human health. Current federal guidance places the cost of carbon emissions at a much higher cost than the estimates used in these studies.[75]

The amount of increased GHG emissions is significantly affected by the assumptions for increased truck transportation. If wheat producers are compensated for increased rail transportation costs, it could significantly reduce the increase in truck transportation as estimated in the 2020 CRSO EIS. The 2020 CRSO EIS notes that shifting from barging to rail and truck would increase transportation-related emissions for wheat that is currently transported along the lower Snake River by up to 53%, or 0.056 MMT of CO_2[76] but emissions changes "would be very small relative to total transportation-related air pollutants in the region."[77] The Jaller study looked at two different coefficients for determining emissions and concluded that, depending on the emission coefficient used, CO_2 emissions from dam breaching could increase 1.37% or decrease by 9.14%. The difference in emissions estimates from the CRSO EIS and the Jaller study is partly attributable to the assumptions around truck ton-mile increases in a dam breaching scenario. The CRSO EIS high estimate of emissions assumes different potential cost increases by railroads up to 50%, resulting in a shift to trucks with higher emissions. The Jaller study assumes no cost increase to the producer. Another factor to consider related to GHG emissions is the difference in GHG emissions between the lower Snake River reservoirs as opposed to a free-flowing river, which is further discussed in the "Emissions" section of this report.

The increased road traffic if not mitigated after dam removal is predicted to result in increased road accidents and fatalities, as well as increased road infrastructure repair and maintenance costs. These costs are based on the estimated increase in truck ton-miles per year because of dam breaching. Because there is a wide range in estimates of increased truck ton-miles, there also is a wide range in estimates for road accidents and other costs. ECONorthwest estimates $48 million to $55 million[BA] in accident costs over 20 years ($3.2 million to $3.6 million annual costs), and $16 million - $19 million[BB] in road wear-and-tear costs over 20 years ($1.1 million to $1.2 million annual costs). Based on the ECONorthwest estimates, over a 50-year time horizon the accident costs total $94.0 million to $108 million[BA] and road wear and tear costs over 50 years would be $32 million to $37 million[BB]. The FCS study estimates annual accident costs of $7 million[BC] ($201 million over 50 years) and $21 million[BD] in additional annual roadway maintenance costs ($627 million over 50 years), for a total of $828 million over 50 years of accident costs and additional road maintenance costs. The 2020 CRSO EIS estimates $5 million annually for road repairs under Scenario 2 and $12 million[BE] annually under Scenario 3. These values translate to $150 million to $370 million in present value road repair costs over 50 years.

Impacts to ports, port-associated businesses, and other businesses

Ports along the lower Snake River play a critical role in the region and support businesses on port properties. Breaching would impact businesses along the river at on-water port sites and associated marinas. Though more analysis would need to be done to fully assess the economic and social impacts associated with dam breaching, there are several broad impacts that can be described.

As discussed above, breaching the LSRD would eliminate barge transportation of wheat and other commodities from the Tri-Cities and the Lewis-Clark (LC) Valley along with the employment benefits the industry provides. There are eight ports along the Snake River that have grain handling facilities. The Port of Whitman provided 131 direct jobs in the grain storage and transportation industry in 2019, representing 4% of the total jobs provided by the Port.[78] According to the 2020 CRSO EIS, barge and tow operators on the Columbia-Snake Navigation System employ approximately 450 people and support employment in other aspects of transportation such as freight, stock and material movers.[17] A portion of the barge and tow employment would be expected to shift to operations below the LSRD, while some employment would shift to other industries such as truck or rail and related support operations.

The Port of Lewiston's barge operations and the Port of Clarkston's cruise ship operations would cease. Associated sites of the Port of Whitman County, including the Port of Almota, Port of Central Ferry, and Port of Wilma have shipping dependent industries that would ultimately be impacted by breaching as the ports would no longer be accessible by barge. Some but not all ports currently served by barge could potentially shift to rail transportation.

Actions needed to replace or improve services

This section describes actions needed to replace or improve upon the existing transportation benefits provided by the LSRD. The loss of Snake River barging as a commodity transportation option will require railroad and road and highway system improvements to handle anticipated traffic increases as commodities previously shipped on barges shift to these methods. It will also require upgrades to transportation-related infrastructure such as commodity storage and handling facilities, and additional railcars. There will also be need for increased funding for road maintenance, and funding for impacted ports. Electric locomotives and lower-emission or hydrogen long-haul trucks are a potential avenue to mitigate some GHG impacts from increased rail and truck traffic.

Upgrading rail infrastructure. Rail infrastructure upgrades include improvements to the regional shortline rail system, developing additional spur lines, confirming the capacity of the main line rail system, purchasing additional unit train cars, and developing new shortline rail to the Tri-Cities.

Improvements to the shortline rail system will be needed to accommodate the volume of wheat currently moved via barge. The shortline rail system in the vicinity of the Snake River includes Columbia – Walla Walla Railway, Camas Prairie Railnet, Columbia Basin Railroad, and the Palouse River & Coulee City Railroad. In Washington there are 1,346 total miles of shortline rail, 600 miles of which are privately owned, and the remaining 746 miles are publicly owned. The longest of these is the 124-mile Palouse River & Coulee City Railroad, which is owned by the Washington State Department of Transportation.[79] The 2020 CRSO EIS noted several improvements needed to improve the shortline system such as interchanges with mainline railroads, and track upgrading.[17]

Updating bridges and tracks to handle 286,000-pound railcars rather than 263,000-pound cars would help handle additional volume as well as provide shortline railroads with better ability to connect with mainline railroads. According to a 2020 WSDOT assessment, only about 55% of surveyed short line railroads can handle the heavier cars.[80] The State of Washington also owns the 19-mile rail line from Colfax to Pullman. The line is currently not in use due to a rail trestle burning down and severing the line but could be returned to service to provide a transportation option for nearby wheat producers depending on how the transportation system shifts and business needs evolve. The CSRO EIS notes that the costs of shortline rail improvements were estimated to range from $35 million to $41 million[BF] ($2.24 million to $2.6 million annualized over 50 years).[17] As noted previously, WSDOT has stated that a transportation impact analysis is needed to provide a more precise cost estimate for transportation-related improvements, including improvements to the shortline rail system.

The Union Pacific and Burlington Northern-Santa Fe are the two mainline railroads operating on the lower Snake River and Columbia River, connecting regional producers with multiple ports in the Pacific Northwest. Discussions with representatives from mainline railroads, reported anecdotally in the 2020 CRSO EIS and again during some stakeholder outreach for this report, indicate that mainline rail capacity is sufficient to handle additional commodity transportation needs. However, there is not complete agreement that mainline rail capacity is sufficient to handle the increased volumes from LSRD breaching, with some stakeholders noting that fluctuations in demand for other commodities shipped by rail, such as petroleum products, can impact mainline capacity. Multiple factors can impact rail capacity, as illustrated by the impacts resulting from the pandemic which has caused significant disruptions to global supply chains. Prevailing conditions at the time of LSRD breaching would impact the interventions required to make the transportation transition as seamless as possible. Capacity on the mainlines would need to be confirmed at such a time.

Another rail infrastructure improvement to add capacity is additional spur lines to provide closer access to rail lines in proximity to wheat producers. These spur lines could, for example, connect to the Watco shortline rail in Lewiston, Idaho. Additional spur line development has occurred as recently as 2019 when Whitgro (since merged with Northwest Grain Growers) installed a mile-long track in Endicott, Washington to accommodate 110 car unit trains.[81]

Another idea included in the Simpson Proposal was to build on the existing shortline system and extend it to the Tri-Cities, where wheat and other commodities could be loaded or off-loaded from Columbia River barges. This would reduce dependence on the mainline railroads and could be operated by a cooperative. In addition, the trains could be moved in part by electric locomotives (currently under development and testing) that would reduce emissions below current levels from the existing transportation system as well as reduce safety hazards by reducing the number of trucks on the road. There is no cost estimate for this concept.

Storage and rail loading and unloading facilities. Upgrading infrastructure for moving commodities from the Snake River region would be needed in addition to rail improvements. This includes increased grain storage capacity at existing or new storage facilities, and build-out of rail handling facilities at Snake River ports where possible. For example, a 2014 report for the Lewis-Clark Valley Metropolitan Planning Organization described how unit train loading capability could be developed at the Port of Lewiston for around $5.4 million[BG].[82] Recommendations and costs differ under various proposals and assessments. For example, the 2020 CRSO EIS suggests the need to construct one to two additional shuttle rail facilities for moving wheat and barley at a cost of $29 million[BH] per facility (for a total cost of $29 million to $58 million).[17] Infrastructure for other commodities currently shipped on the river is also needed, notably fertilizer and sawdust currently barged upriver to supply regional farms and the Clearwater Paper Mill in Lewiston, respectively. This includes improvements to lower Columbia River ports to accommodate additional rail traffic that would result from LSRD removal. The Simpson Proposal also suggested significant capacity improvements (and associated costs) beyond the CRSO EIS and other analyses, such as expanding lower Columbia ports' infrastructure. However, the Simpson Proposal costs are estimated from conversations with stakeholders and not based on a detailed analysis.

Improvements and maintenance to state and local roadways. Road infrastructure of state and local roadways in southeast Washington and north Idaho will require increased maintenance and, in some areas, capacity upgrades to handle additional heavy truck traffic. The CRSO EIS estimates indicate $150 million to $370 million[BE] over 50 years in roadway maintenance costs, depending on the volume of additional truck traffic resulting from LSRD breaching. The FCS study estimates $103 million to $410 million[BJ] in bridge and road repairs in addition to $179 million to $215 million[BK] in state road improvements (for a total of $282 million to $625 million in road and bridge infrastructure improvements), as well as $627 million[BD] in additional road repairs over 50 years as noted above. To identify potential infrastructure investment required for both rail and roads, WSDOT has proposed a planning-level assessment of transportation improvements. A more detailed assessment, e.g., in line with changes in economic conditions resulting from the pandemic, is required to identify needs with a higher degree of confidence.

Ensuring shipping costs remain competitive. The actions described above address road and rail infrastructure capacity required absorb the volume of commodities currently shipped via barge but do not address how cost increases to producers would be mitigated. A key component of the Simpson Proposal addresses the shipping cost issue by creating a trust to compensate traditional Snake River barge shippers with direct payments to producers. The FCS report suggests that increased transportation costs for wheat producers will require a comparable increase in annual federal direct farm payments from $23 million to $45 million[BL], or $686 million to $1.3 billion over 50 years. The ECONorthwest report indicates increased annual shipping costs of $8 million[AZ], which translates into costs over 50 years of $239 million. Regardless of the mechanism used, for example direct payments, a mitigation fund, or other method, Congressional authorization would be needed to compensate farmers. A key consideration is the implications for direct farm payments on international trade agreements including the Agreement on Subsidies and Countervailing Measures, and the WTO Agreement on Agriculture. Further research is required on how to address this issue.

Compensating for economic losses. For certain sectors and entities, the benefits currently provided by the LSRD are not replaceable and therefore require compensation to mitigate the effects of LSRD removal. For example, barging will cease to occur on the Snake River. As a starting point, the Simpson Proposal included providing funding for barging reconfiguration and economic adjustment payments to barge companies and riverboat operators to compensate for lost revenues.

Estimated total transportation improvement and mitigation costs

The various studies of transportation mitigation for LSRD removal illustrated that replacing the benefits provided by the LSRD is possible with the appropriate level of investment. However, the amount of investment needed will require further analysis. WSDOT estimates such an analysis would cost between $5 million and $10 million to assess system performance, develop and model scenarios, analyze scenarios, and run sensitivity analysis. The CRSO EIS estimates that $906 million[CZ] would be needed for dredging and rail/road stabilization. Additional rail or road investments required depend on how much shipping would shift to rail versus truck transportation. If rail rates were not to increase, and rail were to be the predominant mode of transport for freight currently shipped by barge, then investments necessary to increase rail capacity and upgrade existing shortline rail lines would be in the range of $64 million to $99 million[DA]. If rail rates increase by 50%, then no additional rail infrastructure investments may be necessary, but road repair costs could be in the range of $5 to $12 million[BE] annually (to $150 million to $370 million over 50 years, plus additional costs in the form of highway accidents and congestion). In total then, the range of total infrastructure investments for dredging, railroad/road stabilization, new rail facilities, and road repair over 50 years may be approximately $969 million ($906 million plus $63 million) if most shipping goes by rail to potentially $1.3 billion ($906 million plus $388 million) if much shipping transitions to roads. Other analyses, such as the FCS report estimate a need for total capital infrastructure investment between $771 million and $1.2 billion[BN] for similar actions, such as bridge and road repair, state road improvements, rail facility improvements, and other local transportation and infrastructure improvements.[71] The ECONorthwest report, by contrast, estimates the cost of additional road infrastructure between $18 million and $21 million[N] and additional rail infrastructure between $133 million and $159 million[O], for a total of $151 million to $180 million over the 20-year study time period. Table 9 summarizes these cost estimates, as well as the costs presented above for road maintenance, accidents, air emissions, and costs to shippers.

Table 9: Summary of estimated transportation mitigation costs.

Source	Rail, Port, Dredging, and/or Road Capital Improvements	Road Maintenance	Accidents	Air Emissions	Costs/Payments to Agricultural Shippers	Total, All Quantified Costs
CRSO EIS (2020)	$906 million to $1.0 billion	$149 million to $388 million	Not Quantified	Not Quantified	Not Quantified	$969 million to $1.3 billion[i]
FCS (2015)	$771 million to $1.2 billion	$686 million	$209 million	$1.5 billion	$622 million to $1.2 billion	$3.7 billion to $4.8 billion
ECONorthwest (2019)	$151 million to $180 million	$16 million to $19 million	$94 million to $108 million	$42 million	$239 million	$542 million to $588 million
Simpson						$4.5 billion

The CRSO EIS indicates that the estimated road maintenance costs would not be necessary if most shipments went by rail, and that some estimated rail infrastructure improvements would not be necessary if a relative high proportion of shipments went by road, so not all infrastructure costs and road maintenance costs are additive in that analysis.

The variation in cost estimates among the different studies is attributable to the different models and underlying data and assumptions used by the studies' authors. The only report that appears to include downstream dredging costs to deal with sediment associated with dam removal is the 2020 CRSO EIS. The 2020 CRSO EIS, FCS report, ECONorthwest report, and the Simpson Proposal all rely to some extent on information provided by stakeholders to inform their respective cost estimates, some of which is provided through surveys and some of which is provided through personal communications. This information is then used to run different transportation planning models and cost analyses. The 2020 CRSO EIS and ECONorthwest report use different sets of survey data about transportation mode choices, and these data are then used in their models to ascertain how producer and shipper decision-making will occur with LSRD removal. Because the effect of LSRD removal on shipping costs is uncertain, the studies assume different cost scenarios, such as the three scenarios in the CRSO EIS of 0%, 25% and 50% rail rate increase, and 50% to 100% increase in shipping costs in the FCS report. This has a cascading effect throughout the analyses, as these assumptions inform transportation system needs and associated costs. In addition, the FCS and ECONorthwest studies include estimates of the social costs of changes in GHG emissions and roadway accidents, while the other sources do not. Like other estimates, the changes in GHG emissions and roadway accidents, and associated costs, are dependent on data, assumptions, and modeling in the studies.

6. Emissions Impacts

Context

The State of Washington has committed to building a carbon-free future and clean energy economy in recognition of the urgent need to take action to combat climate change. This includes legislation that requires a 45% reduction in greenhouse gas (GHG) emissions by 2030 and a 95% reduction by 2050. Reaching these ambitious goals will require significant GHG emissions reductions in both the energy and transportation sectors, among others.

Analysis by Washington Department of Ecology indicates that a significant portion of the 2030 reductions can be achieved through existing policy and legislation, with some remaining reductions needed through other means, as summarized in Figure 10. Given these goals, many stakeholders asked how the removal of the LSRD would impact greenhouse gas emissions in Washington State and the region.

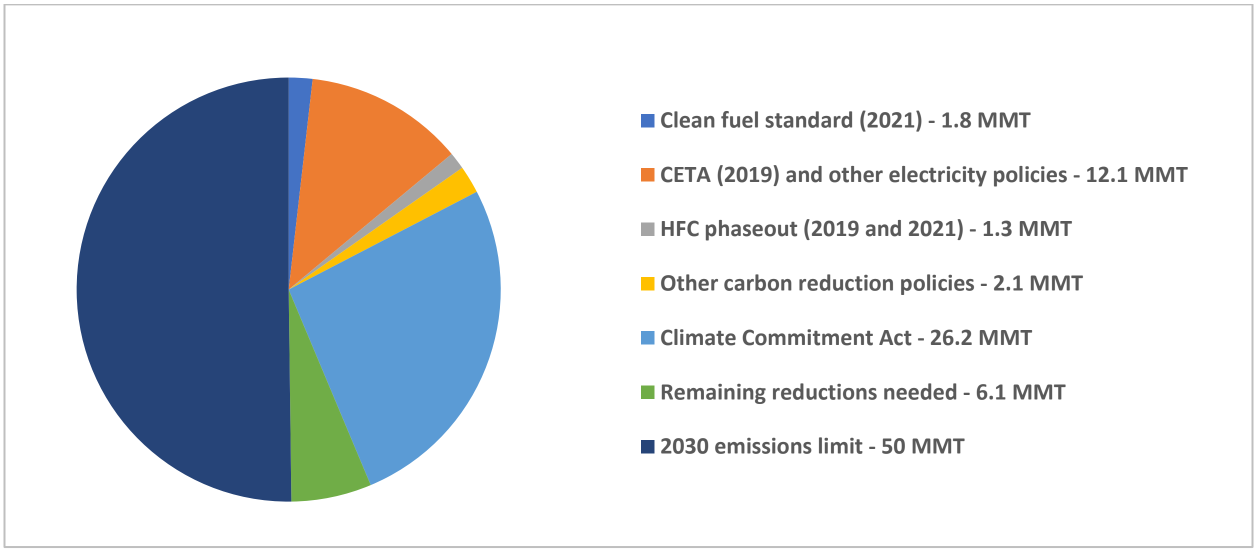

Figure 10: Washington Emissions Reduction Projections for 2030 (source: WA Department of Ecology)

Energy sector emissions

Washington has established requirements to reduce GHG emissions in the electricity sector through the Clean Energy Transformation Act (CETA). Under CETA, utilities must phase out coal-fired electricity by 2025, ensure their portfolios are GHG neutral by 2030, and by 2045 provide 100% clean electricity. Around 16% of Washington's GHG emissions are from electricity consumption.[83] In Washington, a relatively high proportion of emissions are from transportation and industry. Replacing fossil fuels in these sectors with clean electricity is one of the key strategies for achieving economy-wide emission reductions.

Figure 11 illustrates the reference case developed for the 2021 Washington State Energy Strategy where emissions from the energy sector continue their current trajectory through 2050. This scenario assumes Washington meets its clean electricity requirements in CETA but did not enact additional policies to achieve its GHG emissions reduction requirements.

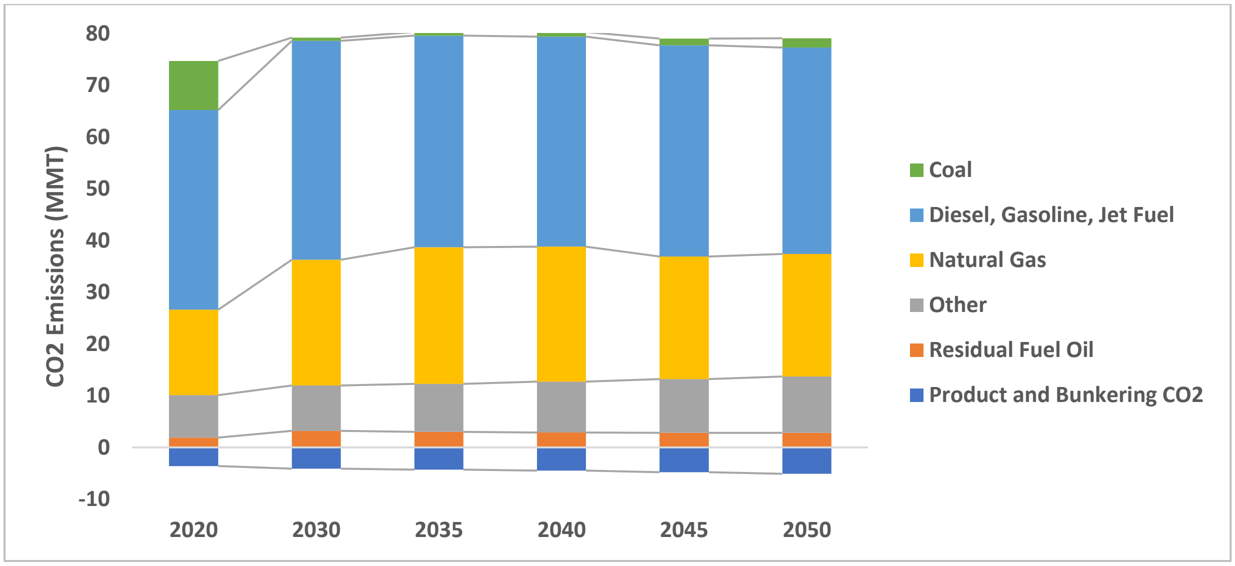

Figure 11: Reference Case for Emissions from Energy Sector by Fuel Source

The Washington State Energy Strategy analyzes various pathways to meet the statutory emissions reduction limits. For example, Figure 12 summarizes the decarbonization pathway in which electrification of the energy sector is the primary pathway to net zero emissions. Under the electrification pathway, Washington will need to replace existing coal and gas-fired power generation and increase clean electricity supplies to replace fossil gas in buildings, produce hydrogen and synthetic fuels, and serve electric vehicles. This will require significant increases in energy efficiency and clean power generation, as well as electric power transmission system expansion. Under the electrification scenario Washington roughly doubles its electricity consumption and its interstate transmission capacity over the next 25 years.[84] However, total energy consumption would decrease, as clean electricity is used to replace less efficient fossil energy in vehicles and buildings.

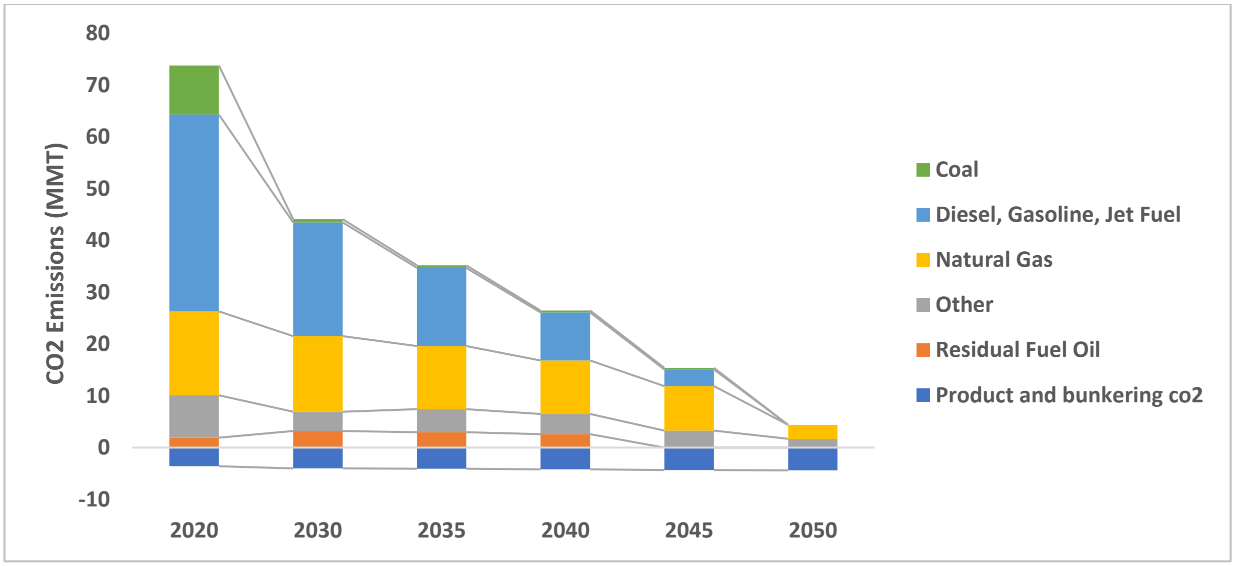

Figure 12: Emissions Profile for Electrification Scenario by Fuel Source

In terms of electricity production, Washington will need an additional 107 TWh, or 12,000 aMW, of clean electricity to fully decarbonize by 2050.[85] A combination of strategies, including electrification, will be required to meet this clean energy goal. The LSRD produce approximately 900 aMW of electricity annually or 5% of the region's energy supply, meaning that removing the LSRD would add incrementally to the projected clean electricity need already anticipated based on Washington's emissions goals.[86]

The CSRO EIS notes that if the LSRD power production is replaced with natural gas, CO_2 emissions will increase by 8.9% or 3.3 million metric tons (MMT) across the Pacific Northwest. The EIS assumes that even if renewable resources are available, some increase in fossil fuel-based generation would occur to maintain system reliability. The zero-carbon replacement scenario analyzed in the EIS shows an increase in power-related emissions of 3.5% or 1.3 MMT of CO_2 across the region.[76]

Substantial development of new renewable and demand side resources will be needed to meet the requirements of Washington's energy and climate policies, and the scientific standards for avoiding catastrophic climate disruption. Over the last 30 years, Washington has developed about 10,000 aMW from wind and energy efficiency alone, and much greater cost-effective potential exists. The costs and impacts of these sweeping energy system changes are difficult to forecast accurately. But assessing the effects of removing the LSRD can only be done against the backdrop of this dynamic future. Fundamental changes in transmission and generation infrastructure, technology, and energy markets are required, with or without the power services of the LSRD. Replacing the dams' services over a decade or more would occur within the context of an energy system transformation, not a return to the 2022 status quo.

Transportation sector emissions

Transportation is the largest source of GHG emissions in Washington State, comprising approximately 45% of total emissions.[84] Since removal of the LSRD would result in changes to the transportation system in southeast Washington, northeast Oregon, and north-central Idaho, the resulting change in greenhouse gas emissions from transportation are an important consideration.

A few reports, including the CRSO EIS, attempt to quantify emissions changes in the transportation sector if the dams breaching, and their conclusions vary. The reports use different transportation models and/or assumptions about modal shifts and associated GHG emissions from barges, trucks, and rail. The following briefly summarizes the conclusions from three reports that analyzed GHG emissions from dam breaching:

- A 2001 study by Casavant and Ball found that, depending on the coefficients used to model emissions, dam breaching could increase emissions by 32,000 pounds, or 1.29%, or decrease emissions by 45,000 pounds, or 2.08%.[87] The study analyzes five GHGS (NO_x, HC, CO, PM, and SO_x) but does not provide data on changes to CO_2 emissions.
- The FCS report commissioned by Pacific Northwest Waterways Association assumes 50% - 100% transportation cost increases because of LSRD removal, which in turn impacts the number of truck and rail miles to transport a similar volume of commodities as currently moved via barge. This increase in truck and rail miles is then converted to annual emissions changes. The report finds that CO_2 emissions will increase by 860,000 tons annually under a dam breaching scenario, with accompanying increases in other emissions (pg. 12).[71]
- The CRSO EIS notes that breaching the LSRD would result in a shift of shipping activities from barge to road and rail transport. LSRD breaching would increase transportation-related emissions for wheat that is currently transported along the lower Snake River by up to 53%, or 0.056 MMT of CO_2.[76]
- A recent study prepared by Dr. Miguel Jaller at UC Davis and commissioned by American Rivers notes that fuel efficiency data for Pacific Northwest transportation modes is limited and depending on the references can have wide variations. Dr. Jaller's study derives estimates of changes in truck ton miles resulting from LSRD breaching and then calculates changes in emissions using two different, recent sources for emissions factors. Depending on which source is used, CO_2 emissions from dam breaching could increase 1.37% or decrease by 9.14%.

Like the energy sector, Washington's transportation sector is also undergoing dynamic changes to meet the state's climate commitments, with several policy and legislative drivers. An important consideration around GHG emissions from the transportation sector is the shift to less carbon-intensive fuels. Washington's Clean Fuel Standard law, which requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 20% below 2017 levels by 2038. It also requires a 15% net increase in in-state liquid biofuel production.[88] In 2021, the Department of Ecology adopted the Advanced Clean Truck (ACT) rule, which requires truck manufacturers to sell an increasing number of zero-emission vehicles by 2035.[89]

Other changes in the transportation sector will also impact GHG emissions. Stronger standards for heavy-duty diesel trucks, including the ACT rule above, are pushing the market for natural gas and hydrogen-powered alternatives. Electric heavy-duty trucks are approaching range and cost levels that will make them competitive with diesel-powered trucks,[90] and electric locomotives are a nascent technology undergoing testing in some parts of the country.[91]

Other emissions

Another issue related to dam breaching and GHG emissions is the projected change in GHG emissions between the existing lower Snake River reservoirs as opposed to a free-flowing river segment. The primary GHG emitted from reservoirs is methane. The 2020 CRSO EIS analysis notes that methane emissions from hydroelectric reservoirs are highly site-specific and depend on many factors such as condition of reservoir sediments, trophic status, and reservoir age (among others). The EIS concludes that GHG emissions from Columbia Basin reservoirs are relatively minor contributors compared to global emissions and suggests several areas of future study to better understand GHG contributions from hydropower projects.[92]

7. Irrigated Agriculture

Overview

The LSRD reservoirs support irrigation on approximately 50,000 acres of farmland in southeast Washington, with most irrigation drawing from the reservoir and water table created by Ice Harbor Dam. The predominant irrigated crops are apples, onions, and potatoes. Irrigated farmland is valued much higher than dryland by acreage, and as such the irrigated farm industry is highly important to the Washington economy. This report assumes that the current level of irrigation along the lower Snake River would be maintained and that no irrigated land would need to be converted to dryland agriculture. The crops grown in the lower Snake River area represent 7% of total production for the state and the estimated combined production in 2021 of all irrigated crops along the Snake River was $327.9 million (approximately $342 million in 2022 dollars) (AgriNorthwest, pers. comm., April 19, 2022).[Z] There are two sources of irrigation along the Snake River: surface water diversion and groundwater wells.

If the LSRD were to be breached, the groundwater level is expected to lower up to 100 feet and the river channel would reestablish itself.[61] As a result, groundwater wells would need to be deepened and outfitted with improved pumping capabilities, and surface water diversion infrastructure would have to be modified to access the newly reestablished channel. Additionally, costs of energy for irrigators would go up as the water will need to be pumped higher as the river channel and groundwater levels go down. Cost estimates for mitigating impacted irrigation from wells and surface water combined range from $188 million[R] to approximately $787 million[P] with $7.4[Q] million in annual maintenance, with variation in assumptions, approaches, and the extent to which irrigation infrastructure would be impacted. Over 50 years, these annual maintenance costs equate to approximately $218 million.

Existing LSRD services

Within five miles of the lower Snake River, there are approximately 50,000 acres of irrigated agricultural land associated with the relevant Water Resource Inventory Areas (33, 34, and 35). According to ECONorthwest, “as there are no major water conveyance projects in the area, this likely captures the range of agricultural land potentially affected by loss of the LSRD” (pg. 67).[31] Irrigated land along the lower Snake River yields a variety of crops such as grapes, apples, onions, potatoes, and sugar beets with fruit trees being the dominant crop within one mile of the river and vegetables being dominant within five miles.[31] The LSRD support irrigated agriculture in two ways: First, water in the LSRD reservoirs is a reliable and predictable resource for irrigators throughout the growing season. Second, the energy provided by the dams ensures that irrigation pumps and equipment can operate without interruption. Replacement of the energy benefits of the LSRD is discussed in Section 7: Energy, while this section focuses on access to water. Although these two types of benefits are discussed separately, the critical relationship between continuous energy and access to water should not be understated.

Critical relationships: energy access and farmland irrigation

During June 2021, the "Heat-Dome" extreme weather event was raised by farmers as a concern along the Snake River. Many irrigators that draw from the Ice Harbor pool received notice of potential rolling blackouts due to high loads, which would have greatly jeopardized their irrigated crops. While these blackouts never came to fruition, one farm had malfunctions to their irrigation systems during this period. Many other farms were required to increase irrigation to decrease the temperatures of the plants and soil. One farm owner's field saw a loss of 20% yield as result of mechanical problems during this short event, while the Columbia Basin as a whole saw yields reductions of 8% to 10% as compared to historical norms, underscoring the important connection between energy reliability during peak times and irrigation.

Most of the irrigated land along the Snake River receives water from the Lake Sacajawea pool behind Ice Harbor Dam – Lake Sacajawea.[93] The pool supports both irrigation from wells and surface water pump diversions. There are 41 wells and 25 direct water withdrawals for agricultural use supported by the water from Lake Sacajawea expected to be impacted by potential breaching.[93] Approximately 84% of the land irrigated along the lower Snake River is by surface water withdrawals pumped up out of the reservoirs to the fields, 6% use wells, and the remainder uses a combination of the two (Table 10).

Table 10: Total number of surface water and groundwater diversions within one mile of the Snake River. ***Note: Not all diversions will be impacted if LSRD are breached.***[31]

Downstream Boundary	Number of Groundwater and/or Well Diversions for Agriculture	Numbers of Surface Water and/or Pump Diversions for Agriculture	Acres Irrigated by Surface and Groundwater Withdrawal
Lower Granite	55	30	90
Little Goose	15	3	162
Lower Monumental	17	9	1,454
Ice Harbor	45	25	51,337
Total	**132**	**67**	**53,043**

Irrigated farmland contributes significantly to local economies, where it can be up to 30 times more profitable than dryland farming and employ 15 times the number of full-time staff throughout the year, and thousands of seasonal workers during harvest. In 2021, irrigated cropland in Washington state had an average production value of $7,800 per acre whereas dryland had an average production value of $1,310 per acre.[94] AgriNorthwest estimates that the combined gross production value of irrigated land along the Snake River in 2021 was $327.9 million (approximately $342 million in 2022 dollars)[z], or 7% of the total 2021 Washington state production for the crops grown in the area (AgriNorthwest, pers. comm., April 19, 2022).

Irrigated agricultural products from the Pacific Northwest are important to the national economy. The broader south central and southeast Washington region produces high-quality product and represents a large share of the national market for certain crops, particularly for potatoes. Processing plants also contribute economically to the region and nationally. AgriNorthwest estimates that in 2021, all irrigated farm products along the lower Snake River contributed $632 million ($660 million[BQ] in 2022 dollars) in processing value from Snake River irrigated farm products (AgriNorthwest, pers. comm., April 19, 2022).

Effects of LSRD removal if not mitigated

Unless changes to agricultural infrastructure are supported as part of mitigation, breaching the LSRD would impact irrigated agriculture by cutting off access to groundwater wells and river pumps that currently draw water from the surface of pools behind the dams. According to the Washington State Department of Ecology Water Rights Tracking System, there are 84 wells and 41 surface water diversions within one mile of the lower Snake River that would need to be altered if the dams were breached.[31] The 2002 EIS, with subsequent engineering analysis, estimated that 71 wells would be affected by dam breaching whereas ECONorthwest estimates 84 wells will be affected. Groundwater could drop up to 100 feet in some areas over the course of two years.[18] During this time, sediment would be flushed through the system, posing a potential issue to irrigation pumps. Downstream from Ice Harbor Dam, small private irrigation pumps pulling from the McNary and John Day Reservoirs may require more frequent maintenance due to increased fine sediment, but large irrigation pumps are expected to be unaffected. The CRSO EIS estimates total regional economic effects at a reduction of $256 million[AA] in labor income, and a loss of approximately $14 million to $19 million[BS] in social welfare, i.e., the net benefits of irrigation or irrigation-related activity to society, annually should the dams be breached, assuming 47,840 acres of irrigated agriculture supported by the dams is unmitigated.[18, 95]

There is a concern by farmers that in the absence of the LSRD river levels would be too low in the summer and fall to maintain irrigation. However, historical water levels prior to LSRD construction indicate that there should be sufficient water to maintain irrigation through months with low precipitation, assuming pump modifications are made.[96] The current standards for limiting water withdrawal have never been reached and would be the same if the dams were breached. As long as the new surface withdrawals continue to use the original water right location, irrigators in the middle and lower Snake River, including those using reservoirs as their water source, would not see any impact on the legal status of their diversionary irrigation water rights from breaching. (Washington Department of Ecology, pers. comm., March 11, 2022). Water rights could be affected if the irrigator changed their diversion to source water from a location within a different legal description. Regardless, policy makers should consider options to identify reasonable solutions if water levels drop significantly post-breaching and if a significant number of individuals need to file an application for change of point of diversion. In contrast to wheat, which is all dryland, transportation of irrigated agricultural products is assumed to be unaffected by dam breaching, as much of it moves directly to processors or to export hubs via truck.

Actions needed to replace or improve services

A variety of replacement actions have been proposed to maintain the benefits provided by the LSRD to irrigated lands and the surrounding agricultural community. In some incidences there would need to be a transition before the permanent solution can be in place which will require interim approaches and potential mitigation.

Deepening of wells and modifications to pumping infrastructure. There are different estimates of the number of wells that would need modification. The 2002 EIS estimated that of the 180 wells within one mile of the Snake River, 71 would be affected by the lowered water table and this value is inclusive of both wells used for irrigation, municipal and industrial pump stations, and private wells.[18] To calculate the number of wells affected by drawdown, the 2002 EIS selected a representative sample to analyze impacts and applied this sample to all wells within one mile of the lower Snake River. The ECONorthwest report estimated that there are 151 wells used for irrigation within one mile of the Snake River and 84 wells would need to be altered.[31] The number of wells needing alteration by ECONorthwest was based on the estimated post-dam well water level as compared to current water levels and did not account for wells with less than an eight-inch diameter.

Table 11 summarizes estimates for the cost of modifying wells. These estimates range significantly, with the 2002 EIS and subsequent engineering analysis estimating a total cost of $147 million[BT] to mitigate 71 wells, and ECONorthwest estimating a total cost of $14 million[BU] to mitigate 84 wells. The 2002 EIS cost estimate assumes that modifications would include increasing the depth of the wells below the estimated new groundwater surface and installing new pumps and associated hardware. Costs estimated in the 2002 EIS were based on analysis by the Drawdown Regional Economic Workgroup (DREW), which applied the average cost per well modification, i.e., $1 million per well,[BV] to the total number of irrigation wells needing modification.[30] The use of municipal and industrial well costs in the average estimate likely accounts for the significantly higher cost than that estimated by ECONorthwest since costs for municipal and industrial well modifications were higher than that of typical irrigation wells. Due to uncertainty of how deep wells would need to be drilled to maintain pre-drawdown rates, the 2002 EIS recommended that the well modifications are made after drawdown.

Table 11: Estimated costs for well modification by source.

Source	Number of Wells	Cost for Well Modification (USD 2022)
Army Corps EIS (2002)	71*	$147 million
ECONorthwest Economic Tradeoff Report (2019)	84	$14 million

**Further engineering review of the well data indicated that about 71 wells rather than the original estimate of 95 were expected to require modification if dam breaching were to occur, but total estimates of costs raised from $56.45 million to $67.04 million (1998 dollars). This increase was not incorporated in the EIS water supply analysis.[30]*

The ECONorthwest report assumed that all wells affected by the lower water table would require full replacement due to uncertainty if their age and condition would accommodate deepening. The cost was estimated based on other regional diversion projects, then scaled to the total costs, inclusive of engineering, permitting and mitigation fees for each well site. The estimate of $14 million[BU] to mitigate for impacted irrigation wells included the costs of drilling, well construction and completion and pump replacement.[31]

During interviews, stakeholders provided their perspectives and information on the cost to deepen wells. In some areas where the wells would need to be deepened by approximately 80 feet, stakeholders anticipate the cost per well could be $400,000 to $450,000 (CSRIA, pers. comm., January 28, 2022). True costs could be investigated further based on available values for updates that have already been performed by landowners. Considering the different estimates, the cost for improving all the current wells could range from $14 million[BU] to $147 million[BT], according to reports, and would be significantly higher according to stakeholders.

However, some short-term economic activity would result from these changes and modifications. For example, modification of wells following breaching would result in short-term construction activity that supports local jobs. The 2002 EIS estimated that construction and other associated activities from irrigation infrastructure mitigation would support nearly 920 jobs in the year of construction.[18] The region near the lower Snake River, because of well modification, could experience a total one-time personal income increase of approximately $58 million.[BW] This economic activity would only be expected to last one year or as long as construction is needed for modification.

Surface water withdrawal modification. Maintaining surface water withdrawal following breaching of the LSRD would require lowering intake structures, creating additional pumping capacity, and other operational changes. According to the Department of Ecology Water Rights Tracking System, there are 41 surface water diversions used for irrigation that would be affected by the removal of the LSRD,[31] with the majority (25) at the Ice Harbor pool. [9696] ECONorthwest considered all impacted surface water diversions along the lower Snake River, including permitted diversions that have not yet been developed. The DREW Water Supply Analysis only considered those diversions pumping Snake River water at the Ice Harbor reservoir. Table 12 summarizes the cost estimates to replace surface water irrigation.

Table 12: Summary of estimated costs of surface water irrigation replacement by source.

Source	Number of Diversions Being Replaced	Upfront Cost	Costs of Annual Maintenance Over 50 Years (not including increased pumping cost)
Army Corps DREW Report (1999)	25	$640 million[P]	$218 million[Q]
ECONorthwest Economic Tradeoff Report (2019)	41	$174 million[CP]	N/A

The 2002 EIS based its estimates for mitigating irrigation on the work of DREW. DREW initially considered three options to modify the surface water irrigation system. Option one was to replace and extend all impacted surface water pumps, option two was to replace all surface water systems with groundwater source systems, and option three was to create a common location for a pumping plant that would connect to all the individual irrigators that utilize water from the Ice Harbor pool.

Option three was determined to avoid the greatest number of problems and uncertainties and would result in the least loss of net farm income. The DREW Water Supply Analysis calculated a total construction cost to mitigate 25 surface water irrigation pumps at Ice Harbor of $640 million[P]. This estimate included six components: (1) a pumping plant at the river, (2) a pipe network, (3) connections to existing irrigation systems, (4) secondary pumping plants, (5) a control system, and (6) a sediment control reservoir.[30] The pumping plant would be located at the narrowest point in the river, which could play a dual role in reducing problems with river fluctuation and meandering, and enabling irrigation to continue before, during and after breaching. The sediment control basin would control surge of fine silts through the system. The total cost of the pump plant system was calculated at approximately $357 million[CQ], inclusive of pre-construction preparation, earthwork for structures, utilities, construction of an access road, pipelines, the pumping plant, and pumping machinery. Construction of the reservoir to mitigate sediment impacts was calculated at approximately $283 million[CR].[30] These two values of $357 million and $283 million sum to the total cost presented above for surface water irrigation pumps of $640 million.

The ECONorthwest Economic Tradeoff Report (2019) contracted Aspect Consulting to calculate estimates of surface water irrigation mitigation. The mitigation of surface water diversion by the ECONorthwest report took on a different configuration than that of the DREW Water Supply Analysis. ECONorthwest assumed each individual pumping station would be replaced and extended, rather than being connected to a pumping plant.[31] The costs to mitigate surface water irrigation was based on reviewing total costs for similar regional diversion projects and fitting an equation to those estimates. The total cost was calculated at $174 million[CP]. Due to uncertainty around sediment impacts and the length of time it would take the river to re-establish and create a stabilized bank fit for permanent pumping infrastructure, there is concern by producers that their irrigated fields would be unable to pull water for one to two years (AgriNorthwest, pers. comm., April 18, 2022). AgriNorthwest suggests an interim mitigation measure of pumping irrigation water from the Columbia River until the Snake River restabilizes. This measure would represent a major cost, taking multiple years to construct. The exact cost of this mitigation is unclear and would require scoping.

Table 13: Surface water diversion mitigation cost estimates based on flow rates and diversion location.[31]

q1 Range (cfs)	Number of Diversion Locations Included in Cost Estimate	Sum of q1 (cfs)	Estimated Replacement Cost
> 100	2	423.6	$60 million[CT]
10 to 100	12	516.3	$97 million[CU]
1.0 to 10	15	47.6	$14 million[CV]
.1 to 1.0	12	7.5	$3 million[CW]
Totals	**41**	**994.9**	**$174 million[CP]**

The DREW study anticipates continued irrigation throughout breaching and manages for sediment, however it is significantly more expensive. Extending each pump for surface water diversion individually, as outlined in the ECONorthwest report, costs less but also has differences in timing. Breaching the LSRD would change water levels in the river channel, allow the channel to move and reestablish, and increase the amount of silt in river water, especially in the two to seven years immediately after breaching.[33] Because the exact location of the river channel will emerge over time, it may not be possible to confidently relocate individual surface water withdrawals before breaching or even immediately after it. Similarly, there can be efforts made prior to potential dam breaching to identify temporary water supplies which irrigators could access as the river re-establishes itself.

In addition to changes needed to maintain access to water in the new river channel, efforts also will be needed to address increased siltation. There are some proposed preventative actions that could slow water and reduce ongoing problems with sediment. Namely, American Rivers references the opportunity to use river back channels (natural or artificial) to slow the water as drawdown occurs and reduce the buildup of sediments near irrigation pumps and wells.[96] No cost estimate was provided to create back channels.[96] There may also be some downstream impacts to irrigation pumps on the lower Columbia River as sediment is released from behind the LSRD reservoirs. In the short-term, annual sediment volume is expected to be 12.6 million cubic yards (Mcy), slowing down to a new quasi-equilibrium of 2.6 Mcy entering McNary Reservoir in the long-term. The CRSO EIS estimates that up to 35% of the total fine sediment, i.e., silt and clay, entering McNary Reservoir would remain in suspension and travel to the estuary. These suspended sediments may cause issues at irrigators intakes below McNary Dam. The estimates for replacing irrigation infrastructure in this report does not account for potential maintenance or adjustments to infrastructure needed by the short-term impacts of silt on the lower Columbia River.

Investigation of increased energy costs to irrigators. Energy can represent 15% of the total cost of production for irrigated agricultural products and may be impacted by breaching (AgriNorthwest, pers. comm. March 4, 2022). Pumps will be required to lift irrigated water higher, and would require greater horsepower, translating to increased energy use.[30] The difference in costs for energy could be calculated by looking at by analyzing the change in groundwater in elevation and the cost per foot to lift water based on flow rates. This could represent an additional cost to farmers in the future and should be investigated.

Estimated total irrigation mitigation costs

Multiple studies on irrigation mitigation for LSRD removal find that it is possible to replace the benefits provided by the LSRD and maintain irrigated farming along the lower Snake River. However, the costs to replace irrigation infrastructure in the event of breaching would be borne by the landowners and farm businesses in the local economy, unless a relief package were put together to support the transition. In order to mitigate both wells and surface water irrigation, as described above, the 2002 EIS estimated that mitigation would include up-front costs to replace infrastructure of up to $787 million[P] with an additional maintenance cost over 50 years of $218 million[Q] for surface water withdrawal. Upfront costs include deepening 71 wells and modifying adjusted related infrastructure and creating a common pump location for 25 Ice Harbor irrigators. The ECONorthwest report estimated a total infrastructure investment of $188 million[CY] to deepen 84 wells and modify related infrastructure and mitigate for 41 surface water withdrawals along the lower

Snake River. The Simpson Proposal provided up to $750 million[G] in funding to carry out any structural changes required for affected irrigation intakes, outflows, wells or other structures related to irrigation along the lower Snake River. Table 14 summarizes these cost estimates.

American Rivers also noted that some land that was inundated by the pools behind the LSRD was previously farmland. In the event the dams were to be breached, the land would be uncovered and could potentially be used as farmland again in the future, representing a new source of income for Snake River farmers.[96]

Table 14: Summary of estimated irrigation mitigation costs

Source	Estimated Irrigation Mitigation Cost
Army Corps EIS (2002)	$1.0 billion ($787 million capital cost, and $218 million present value maintenance cost)
ECONorthwest (2019)	$188 million
Simpson Proposal (2020)	$750 million

8. Energy Replacement

Overview

The LSRD are part of the broader integrated system of hydroelectric facilities from the Columbia River and its major tributaries. While these four dams are operated and maintained by the Army Corps, the energy that they generate is sold and marketed by the Bonneville Power Administration (BPA), a self-funded, non-profit federal power marketing administration within the U.S. Department of Energy, primarily to utilities within the Pacific Northwest region. The Pacific Northwest region is defined by the Northwest Power Act as "the Columbia River basin plus areas outside of the basin where the Bonneville Power Administration is able to sell firm power" (Figure 13).[97, 98] BPA's service area, i.e., the Pacific Northwest region, is the geographic scope for the information in this section of the report. The Pacific Northwest region currently has about 63,000 MW of generation installed within or just outside of this region and under contract, however some of the installed generation within the region is contracted to serve customers outside of the region.[99]

This section summarizes the current power attributes and services of the dams, changes in the overall Pacific Northwest energy environment, and actions to replace the current power attributes if the dams were breached. Replacing energy production as well as the electric grid services provided by the LSRD is possible. It would take time, funding, planning, and collaboration across all stakeholders to ensure that the region's future clean-energy goals are met, customers (especially the most vulnerable) are not overly burdened by increased electricity rates, and system reliability remains in compliance with regional and federal standards, including the North American Electric Reliability Corporation (NERC) and Western Electricity Coordination Council (WECC). [100, 101]

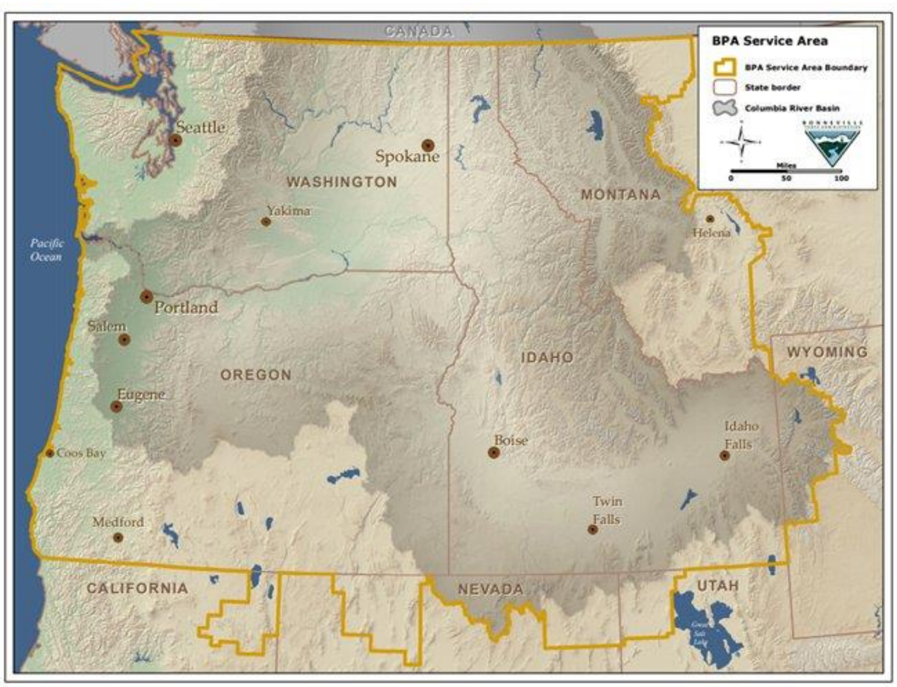

Figure 13: Map of Pacific Northwest region.[97]

This section also summarizes the paradigm shift occurring in the Pacific Northwest region. Decreasing costs for renewable energy sources, compliance with clean energy requirements, decarbonization of transportation and the building environment, and shifts in energy demand caused by climate change all add up to unprecedented changes for electricity demand and supply over the next couple of decades. Consideration of the future of the LSRD needs to take into account the future energy needs of the Pacific Northwest region. Interviews with experts highlighted two important factors to consider in replacing the energy attributes of the LSRD. First, a replacement portfolio should be in place and demonstrating that it is producing energy and providing services to the grid before the dams were breached to avoid significant impacts to the regional energy system and the communities it serves. Second, in addition to evaluating a one-to-one replacement portfolio, an option for replacing the energy attributes of the LSRD should be evaluated that optimizes the ability to meet the Pacific Northwest region's current and future needs, not just what the LSRD currently provide and when they provide it.

Existing services of the LSRD

This section describes the types of energy services currently provided by the LSRD, including annual energy production, peaking capacity, clean energy, grid stability, ancillary and grid services, transmission services and lower regional energy rates.

Annual energy production

Each year the LSRD produce an average of 900 average Megawatts (aMW) of energy.[86] An aMW is defined as one million watts of energy delivered continuously 24-hours a day for a year. This energy from the LSRD is non-emitting[102] and represents about 4.3% of all generation within the Pacific Northwest energy system and about 11% of BPA's entire system generation.[103]

The generation from the dams varies significantly from month-to-month and year-to-year with variations in river flows. Figure 14 shows average monthly generation amounts throughout the year based upon generation data from 2013 to 2019. The LSRD generate the most of their annual generation during the spring runoff period from mid-April to early June. The figure also shows the maximum and minimum hourly generation levels for the dams over the same period, showing the large differences in generation the dams can produce depending on the grid and market conditions.

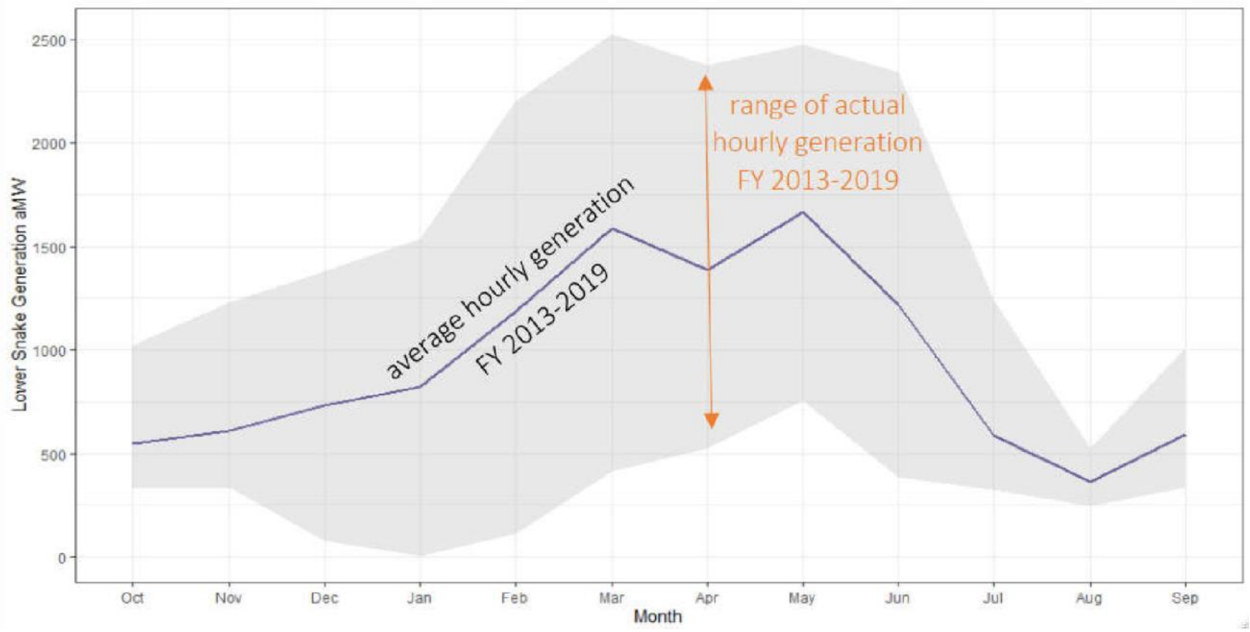

Figure 14: Lower Snake River Dam average monthly generation from FY 2013 – 2019 (top) with range of hourly generation for the same period (bottom). Source: Benton PUD, USACE Water Control Data.

Dispatchable and peaking capacity

The LSRD have the ability to change their energy output quickly to help meet regional demands and to provide peak energy production during high-load times for multiple hours and even days. Electricity generating resources vary in how quickly they can respond to meet demand. A resource with output that can be controlled by its operator is referred to as a "dispatchable resource." The ability of an energy source to be dispatchable is determined by the availability of the fuel source that the generation type leverages to produce power. For hydropower, the project must have sufficient water supply for generation in addition to meeting other regulatory obligations. For wind and solar generation, environmental conditions must be conducive to generation. For combustion generation, the project must have either gas or coal available. Energy from the LSRD is highly dispatchable at times when water is available. However, the LSRD are run-of-river dams and have limited storage in contrast to the other larger Columbia Basin hydro projects that can store water in their reservoirs and have a higher ability to provide capacity.

BPA uses energy produced from the LSRD throughout the year, especially during peak demands which is most often in the winter months when energy loads are high due to individuals heating their homes. During cold snaps or emergency situations when energy production from other forms of generation may be negligible or unavailable, the LSRD could theoretically produce a peak capacity of 3,483 MW of energy, representing about 15% of BPA's total peaking capacity, and provide 2,300 MW of firm peaking capacity.[86] The LSRD produced just under 1,600 MW of energy during a recent extreme weather event that took place during the summer when flows are typically lower.[104] The LSRD have the ability to quickly ramp up energy production within minutes to meet loads. Dispatchable resources of the broader hydrosystem, including the LSRD, are important to overall system reliability because of their ability to quickly react to losses of generation sources in other parts of the grid or large increases in demand due to extreme weather events.

The LSRD can provide variable levels of peaking capacity year-round, particularly in the winter, which is difficult to achieve or replace through other available carbon-free resources. The LSRD can provide the highest levels of peaking capacity when water levels are sufficient, primarily during the spring runoff. Peaking capacity is most needed in winter and summer months when energy demand is high and weather extremes are most frequent. During winter cold snaps in the Pacific Northwest, which are likely to occur from December to February, the LSRD have traditionally produced above average generation levels, and as climate change progresses, precipitation trends are expected to result in more generation during the winter as more precipitation falls as rain rather than snow.[104] Climate change also is predicted to cause more interannual variation, meaning increased variability from historic climate patterns that have been traditionally utilized for forecasting, further complicating the ability to forecast future winter sustained peaking capacity.

Peak energy demand also can occur in the summer if a heat wave forces residents to increase air conditioning use. Heat waves most commonly occur in late summer. While heat waves can occur throughout the summer, the most challenging heat waves from a power perspective most commonly occur in late summer. Fortunately, although the LSRD have declining flows and generation during summer months, under current operations, spill for fish passage reduces to surface collector flow only in mid-August because the fall Chinook outmigrating is tapering off and Bonneville is able to request operations that shape more generation into hours of peak demand during late summer heat waves. While the effects of climate change and increasing constraints for fish protection may reduce the output of the LSRD during the summer, the non-emitting baseload energy production the LSRD provide is expected to become more valuable to the energy system in the summer due to the retirement of thermal generation in the region.[66]

Non-emitting energy

The LSRD operate within the broader Columbia River hydroelectric system, which produces non-emitting hydropower and allows the region to have some of the least carbon emitting electricity generation in the country. Pacific Northwest electricity has roughly half the carbon intensity of the U.S. average, in large part due to hydropower.[105] The ability of the LSRD to quickly ramp up and down energy production assists in the integration of intermittent resources like wind and solar, which are reliant on environmental factors that can be more variable in production of energy depending on the time of day and weather conditions.

Transmission services and grid resiliency

In addition to annual energy production, dispatchable resources and peaking capacity, the LSRD provide transmission stability and grid resiliency. Electrical transmission is the distribution of electricity from generation sources to end-users over power lines, oftentimes moving energy from rural sources to urban centers. Currently, BPA is the largest owner of transmission lines in the Pacific Northwest operating about 15,000 miles of lines that represent about 75% of all the transmission in the region.[106] The larger Pacific Northwest region is comprised of smaller transmission interfaces that serve the load of local areas using their lower voltage lines and also facilitate the flow of electricity to other portions of the grid along their higher voltage lines.[107] One important example of this is the Tri-Cities transmission interface, which consists of transmission lines and transformers used to provide energy services to Kennewick, Pasco, and Richland. Due to the location of the LSRD within the transmission interface, the LSRD allow power managers to distribute energy efficiently throughout the Pacific Northwest grid to maintain the reliability of the transmission and to minimize power costs[108] The generation at Ice Harbor Dam is embedded, or co-located, with the loads in the Tri-Cities, making it an important source of power to serve the Tri-Cities area, particularly during peak summer load conditions.[108]

Due to current limits on transmission infrastructure into the Tri-Cities area, an outage of one of the transmission lines connecting the Tri-Cities area to the main transmission grid substantially limits the amount of energy that can be delivered to the Tri-Cities area. During such outages, generation from Ice Harbor ensures reliable service to the Tri-Cities area.[108] The generation at Ice Harbor also allows BPA to take lines out of service for planned maintenance and other operational reasons without affecting reliable service to the Tri-Cities area. The inability to take lines out of service for maintenance and to respond to operational constraints, such as the loss of a transmission line, could increase risk to transmission system reliability and result in loss of load to the Tri-Cities area.[108] However, the Columbia Generation Station is the dominant generation resource in this region and transmission line upgrades and maintenance will continue if the LSRD remain or are breached. (Pers. Comm, NWEC, July 8, 2022)

The location of the LSRD also is important for maintaining overall grid resiliency in the Pacific Northwest by adjusting the sources of generation in response to fluctuations in energy demand. The LSRD provide additional grid resiliency services like flexible capacity, frequency response and regulation, voltage control and inertia. Hydropower projects like the LSRD do not always operate at full capacity, they can easily ramp up and down in energy production to meet loads in real time by allowing more or less water to pass through turbines to meet loads in real-time by automatically allowing the energy system to safely respond to large swings in either load or generation .[108]

Low power rates

The Columbia Basin hydroelectric system, which includes the LSRD, contribute to some of the lowest power rates for customers in the Pacific Northwest, compared to other rate payers in the United States. One factor that keeps power rates low is that BPA is able to sell a certain amount of surplus energy produced by the federal hydrosystem to recover total system costs.

A recent BPA analysis projected the average cost of generation and fully loaded cost at the different plants that comprise the Columbia Basin hydroelectric system.[22] Cost of generation is defined as "the direct cost and administrative overheads of producing power at a plant, and includes operations, maintenance, administrative and capital related costs." Fully loaded cost is defined as "all costs of doing business associated with the hydro plant operations, power marketing and delivery…[and] includes other allocable costs to the hydro system such as BPA's Fish and Wildlife program, Residential Exchange, transmission acquisition and other obligations."[22] Table 15 summarizes the average projected costs of these power metrics over the next 50 years. Mainstem Columbia River dams are six high generation dams that generate the majority of power for the federal hydroelectric system. The LSRD are the four dams analyzed in this report, including Ice Harbor, Lower Monumental, Little Goose and Lower Granite. The Headwater dams are three dams at the headwaters of the Columbia and lower Snake Rivers, including Libby, Hungry Horse and Dworshak. Table 15 shows the comparison of average and fully loaded costs of the Main Stem Columbia, four Lower Snake, and Headwater dams within the Columbia Basin hydroelectric system.

Table 15: Projected average and fully loaded costs of generation by resource region in MW per hour over the next 50 years.[23]

Resource	Cost of Generation ($/MWh)	Fully Loaded Cost ($/MWh)	Average Annual Contribution (aMW)
Main stem Columbia	7.54	19.04	6,736
Lower Snake	12.13	29.08	900
Headwater	11.76	23.56	565

Changing energy environment

There is a major paradigm shift occurring in the Pacific Northwest Energy System which is important to understand in relation to the prospect of breaching the LSRD. There are broad changes in the social, political, physical and economic drivers affecting the Pacific Northwest Energy System. These changes are driven by regulatory and policy changes as the region is turning toward cleaner renewable sources of generation, primarily wind and solar. The Northwest Power and Conservation Council (NWPCC) notes that these renewable sources are becoming less expensive to build and are seen as the primary path to reducing emissions associated with generating electricity, and increasing energy efficiency and demand response.[99] In addition, changes in energy demand resulting from climate effects, decarbonization of the transportation and building environment, as well as changing legal structures, like BPA contracts and the Columbia River Treaty, provide a level of change and uncertainty that is unprecedented. These changes, the risks associated with them, and the critical importance of reliability creates uncertainty about the amount of future development needed for low-cost renewable resources and the availability of transmission capacity needed to move these resources to load centers. There also is uncertainty about whether western market energy resources will be available to the region when needed to reduce costs or meet demand.

The changes mentioned above are important to consider because replacing the energy provided by the LSRD will not happen in a vacuum. Any changes to the region's baseline energy generation will affect how all utilities within the Pacific Northwest Energy System operate, altering utilities' plans for dealing with the multiple challenges that they currently face, such as climate change, new regulations, forecasted retirements of coal plants and increased loads due to the electrification of the transportation sector. The different issues described below provide both opportunities as well as challenges to meet the complex anticipated future energy needs of the region.

Clean energy requirements

One of the largest drivers for change in the Pacific Northwest energy environment is the adoption of carbon-free energy laws and policies across the four states of Washington, Oregon, Idaho and Montana. The Washington Clean Energy Transformation Act (CETA) requires all utilities in Washington to provide carbon-neutral electricity by 2030, with all coal to be phased out of the Washington energy grid by 2025 and 100% clean energy by 2045.[109] In 2021, Oregon followed Washington's lead by adopting its own clean energy legislation.[110] As a result, both states now require utilities to eliminate coal and gas generation from their respective portfolios by 2045 or sooner. Additionally, the Idaho Power Company, Idaho's largest energy provider, has made a similar commitment for its power supply, and NorthWestern Energy in Montana has committed to reduce their carbon portfolio to 90% of what it was in 2010 by 2045.[5] It should be noted that Idaho Falls Power is looking to develop additional gas generation facilities, so it could be possible to construct new gas generation outside of Washington and Oregon, but still within BPA's service area.

A low-carbon future hinges on an integrated energy economy where power sources, particularly electricity, play a cross-sectoral role in transportation, and the built environment must transition from the carbon energy sources used by transportation, buildings and businesses as well as in the production of electricity. In a 2019 Clean Energy Transition Institute study, widespread transportation electrification, or 100% of light-duty, 60% of medium-duty, and 40% of heavy-duty vehicles in the study's Central Case, will be crucial to reduce emissions at least cost and avoid using either scarce biofuel supplies or relatively expensive electric fuels for transport.[111] Clean electricity also needs to replace oil and gas to heat and cool buildings in a low-carbon future. Finally, clean electricity will need to be used to produce synthetic gas and liquids as additional energy sources. All these changes will increase the demand for clean electricity in the Pacific Northwest Energy System.

Concurrent with and as a result of these clean energy initiatives, many coal-fired generation sources are set to be retired by 2035, notably the Centralia Coal Power Plant as well as additional investor-owned coal power plants. Since 2019, 2,100 MW of coal-fired power has been retired in the Pacific Northwest, with an additional 2,800 MW scheduled for retirement by 2026. Of the 2,800 MW scheduled for retirement, 1,100 MW is planned to transition to gas generation to reduce carbon intensity.[112] Figure 15 summarizes projected retirements in coal-fired power generation in the Pacific Northwest.

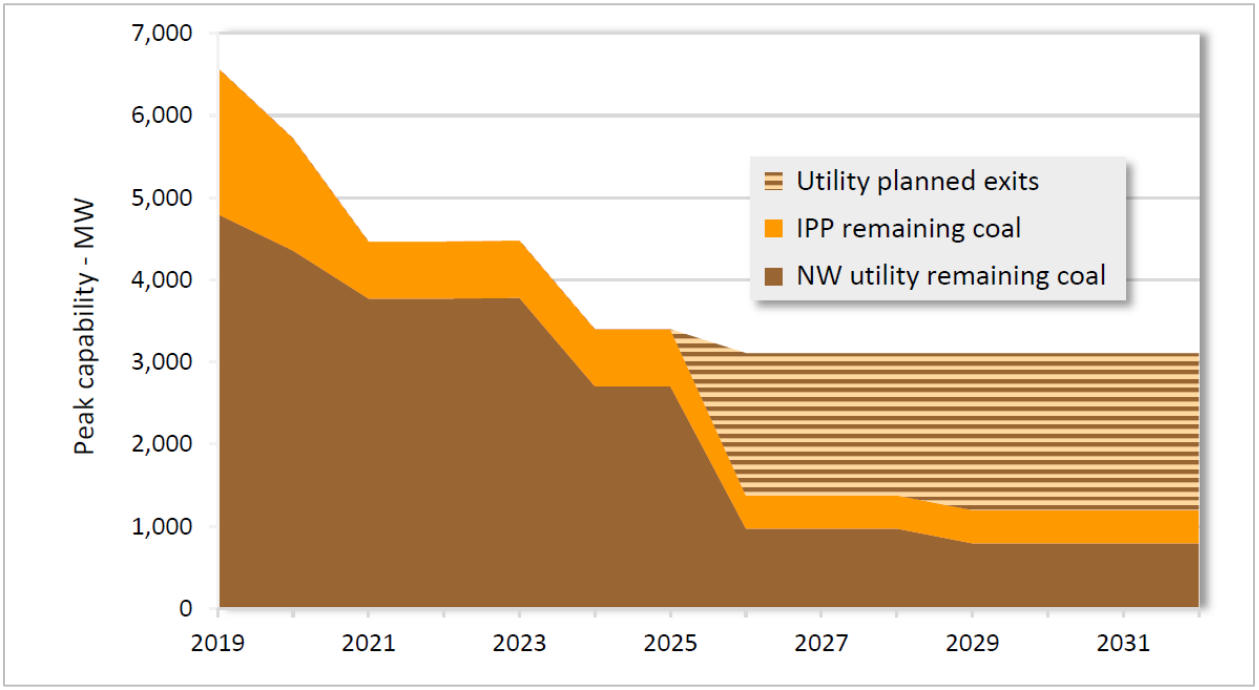

Figure 15: Projected retirements in coal-fired generation in the Pacific Northwest between 2019 and 2032.[112]

Many of these coal retirements are being replaced by renewable resource portfolios. For instance, in Idaho Power's most recent Integrated Resource Plan (IRP) the replacement portfolios for the planned retirement of three of the Jim Bridger Coal Plant units in Wyoming identified the need to develop 700 MW of wind, 1,105 MW of solar and 585 MW of battery storage by 2030, a significant increase in projected renewable development compared to their previous IRP.[113] Similarly, Portland General & Electric in their most recent IRP identifies a replacement portfolio for the retirement of Colstrip units 3 and 4 in Montana that identified an additional 293 MW of wind resources by 2028. While both replacement portfolios are replacing smaller base load resources compared to the LSRD, i.e.,841 MW for Jim Bridger and 296 MW for Colstrip, both show that the region is currently planning and has the ability to replace base load resources with intermittent renewable resources. However, the effect that wide-scale development and reliance on renewables will have on grid resiliency and reliability is still not clear.

Changes in energy demand

Over the past decade the energy needs of the Pacific Northwest have shifted and will continue to shift into the future. In 2019 the Pacific Northwest region produced 26,245 aMW of energy.[99] The most recent NWPCC Power Plan projects that annual energy consumption is expected to continue growing in the future due to a number of factors like economic growth, climate change, increased use of air conditioning in homes, regional demographics and increased use of electric vehicles to decarbonize the transportation sector. Under expected economic conditions without additional clean energy policy legislation, the NWPCC expects the region to increase its electrical energy consumption by about 9.4% by 2041. The largest increase is expected to occur in the transportation sector, with an estimated increase of 12 times the annual consumption compared to 2021.[99] Due to the recently passed "Move Ahead Washington" transportation package, the shift towards electrification of the transportation sector is expected to outpace the rate that was anticipated in the NWPCC Power Plan. The package calls for the phasing out of traditional combustion vehicles so that all new publicly and privately owned light duty vehicles registered in the state have to be electric by 2030.[114] In the 2021 Washington State Energy Plan, if the large-scale adoption of electrified transportation fuels and end uses is achieved, energy demand is expected to grow 97% higher than 2020 levels by 2050.[115]

Because of relatively cool summers and low rates of air conditioning, the Pacific Northwest's peak demand has historically occurred in the winter, when more people are using heat. This is shifting due to higher summer temperatures causing increases in air conditioning use. The difference between winter and summer peak usage is expected to shrink over time unless there is substantial electrification of residential and commercial building space heating. Within the Snake River Basin, most climate change projections indicate greater warming than other regions in the Columbia River Basin, and on average summer flow volumes are expected to decrease. However, there is uncertainty within climate change projections on summer precipitation levels and extreme low flows are expected to have little change or small increases in severity. For the winter and spring, precipitation is expected to increase and result in higher fall and winter flows and earlier and higher spring flow peaks. Models suggest that as early as the 2030s, snowpack in the Snake River Basin is likely to decrease with streamflow timing changes appearing earlier here than other parts of the Columbia River Basin.[116] The NWPCC projects under expected economic conditions without additional clean energy policy legislation that combined climate change impacts on loads and hydropower may lead to decreases in winter shortfalls, and increases in summer shortfalls as increases in peak loads for cooling coincide with decreases in hydropower generation due to lower river flows.[99] Those models, and the Washington State utilities that also model the LSRDs in their long-term plans, include the contributions of the LSRD to help meet all seasonal needs. New analysis comparing the high electrification of transportation, buildings, and industry with the NWPCC's projections resulted in an additional annual energy demand increase of 28% by 2045 and an additional winter peak demand increase of 68% above the NWPCC's projections. The peak demand increase is high due to the electrification of space heating end uses, which requires replacing the significant quantities of energy provided by the natural gas system during extreme wintertime cold weather events with electricity.[86]

Climate change is also expected to alter the traditional wind regime for the Pacific Northwest. The NWPCC found that southeast Washington and Montana are expected to have lower summer generation levels and higher winter generation levels, with the highest generation levels from November to January. The inverse is anticipated to happen in the Central Washington Gorge region, with increased summer generation and lower winter generation from its current consistent wind regime.[117]

Increases in renewable energy sources

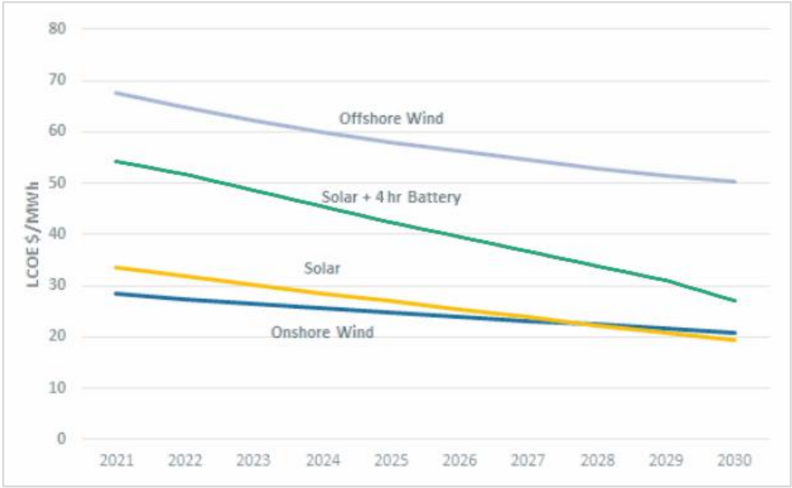

Figure 16: Current (2021) and projected cost of renewable generation resources in estimated dollars per MW hour from 2021 to 2030.[118]

Costs for solar and wind energy production have declined dramatically over the last decade and more significant reductions are expected. These cost reductions make solar and wind a primary source for replacing carbon generating sources, meeting increased demand, and replacing the annual energy production from the LSRD. Figure 16 shows the current (2021) and levelized projected cost of energy, in dollars per megawatt-hour, across the major clean energy sources, including offshore wind, onshore wind, solar, and solar plus battery, from 2021 to 2030.[118]

To meet future regional power needs the NWPCC projects that by 2040 over 350,000 MW of renewables will need to be developed across the larger Western Interconnection, which extends from British Columbia, Canada down to Baja, Mexico and includes all states west of the Rocky Mountains as well as some parts of Texas.[111] The Pacific Northwest region is interconnected within this broader system and the NWPCC recommends that at least 3,500 MW of renewable resources be acquired by the local region by 2027, and projects the local region may need around 10,000 MW of renewable resources by 2040 under base conditions, and around 35,000 MW by 2040 under a partial decarbonization scenario. Because of the high projected increase in renewables and due to the intermittent nature of renewable sources and the expected low cost for constructing these resources, it is assumed that "overbuilding" the system to meet peaking capacity needs will be less costly than alternative sources of capacity that have direct greenhouse gas emissions.[119] Currently there is a total of 63,000 MW of nameplate generation installed in the Pacific Northwest Region, which is nearly a quarter of the entire 270,000 MW nameplate generation in the entire Western Interconnection. Figure 17 shows the forecasted scale of new generation needed across the Western Interconnection and the projected sources to meet the need by 2040.[99]

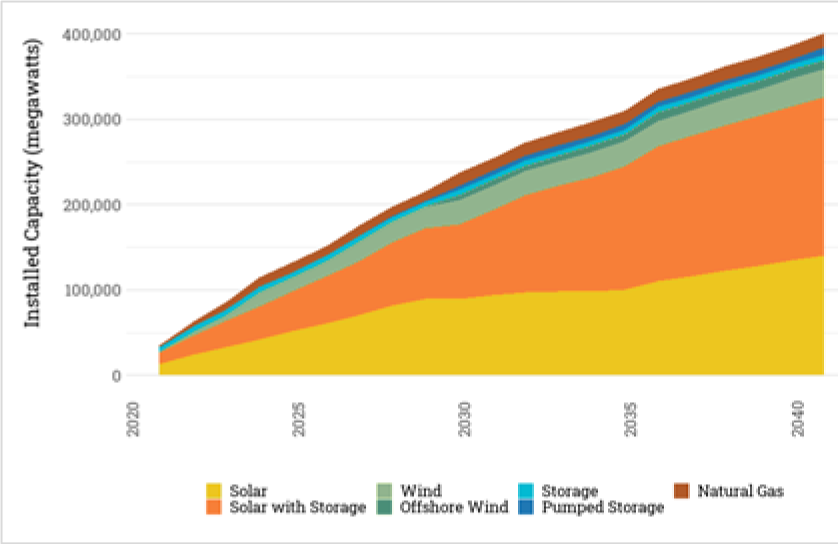

Figure 17: Projected increases in renewable generation by sources for the West Coast Grid System between 2020 and 2040.[99]

Both wind and solar require large amounts of land to generate similar levels of power as traditional carbon emitting resources. For example, to generate one MW requires on average seven acres of solar panels.[120] Developing additional wind and solar facilities will require successfully addressing environmental issues, cultural resources and community concerns associated with their siting. In addition, increasing the amount of renewable, intermittent sources like solar and wind will require changes in how the hydrosystem is used by storing more water during daylight time and windy periods, when there is excess power, and releasing more water to match evening peaks. The fluctuation in water levels will need to be performed in a manner that does not increase impacts to aquatic species and salmon in particular.

As shown in Figure 18, an Energy Pathways study estimated changes to future generation levels in order to reach at or below 1990 emissions levels by 2050, which would provide an 80% reduction in total CO_2 emissions across the entire Pacific Northwest region. The study found that annual generation of renewables will need to increase by 60% in 2050 compared to 2020 generation levels to reach decarbonization. The Energy Pathways study assumed that the amount of baseline generation from hydropower stays consistent, so any reductions to the amount of hydropower baseline generation, e.g., due to breaching the LSRD, will require development in additional non-emitting resources to reach this goal.

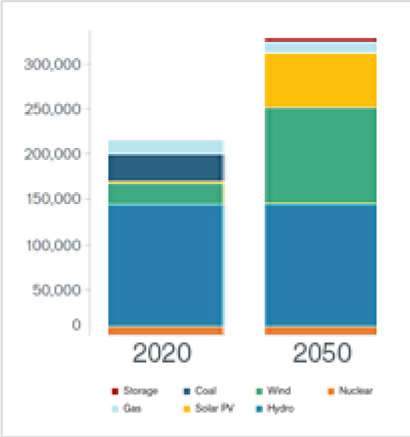

Figure 18: Current and projected future electricity generation by source in 2020 and 2050 for the Pacific Northwest.[111]

Greenhouse Gas (GHG) Emissions

Washington state has established requirements to reduce GHG emissions in the electricity sector through the Clean Energy Transformation Act (CETA). Under CETA, utilities must phase out coal-fired electricity by 2025, ensure their portfolios are GHG neutral by 2030, and by 2045 provide 100% clean electricity. Around 16% of Washington's GHG emissions are from electricity consumption. The Washington State Energy Strategy analyzes various pathways to meet the statutory emissions reduction limits. For example, Figure 19 summarizes the decarbonization pathway in which electrification of the energy sector is the primary pathway to net zero emissions. Under the electrification pathway, Washington will need to build new clean energy generating plants and significantly expand the electric power transmission system, because it needs additional electricity resources not just to replace existing coal- and natural gas-fired generation resources but also to provide clean electricity to propel battery electric vehicles, produce hydrogen and synthetic fuels, and replace fossil gas in buildings and factories. Under the electrification scenario Washington roughly doubles its electricity consumption and its interstate transmission capacity over the next 25 years. In contrast to Washington state's schedule for meeting emission requirements, a recent Energy GPS study commissioned by Northwest RiverPartners forecasted that even if the region were to double its historic pace of renewable buildout, it is unlikely that state requirements are met until 2076, causing emissions in the Pacific Northwest to increase by 132 MMT of CO_2 to maintain grid reliability.[121]

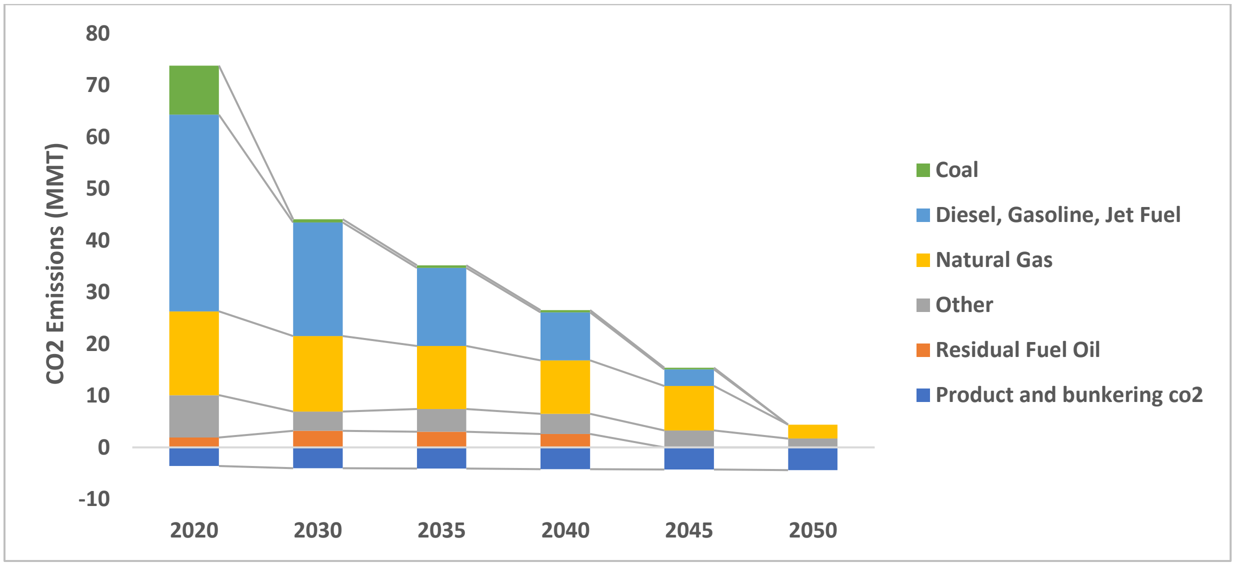

Figure 19: Emissions profile for electrification scenario by fuel source.

Technology advances

The rapid pace of technological advances is seen by many energy experts as a positive indicator to support growth of renewable energy sources and expand their contribution beyond when the sun is shining, or the wind is blowing. Industry experts expect even more significant advancements in technology for batteries and ways to optimize demand in the next five to 10 years, which will provide more options and flexibility to meet future energy demands.

One of the main new technologies being used for peaking energy needs is battery storage in combination with renewable sources like wind and solar. The rapid expansion of this technology is demonstrated by the California Independent Service Operator's (CAISO) recent updates where they currently have 3,500 MW of battery storage and expect to have 5,950 by the end of 2022 (CAISO, pers. comm. May 16, 2022).[†] Additionally, Pacific Gas and Electric (PG&E) was recently approved to build 1,598.7MW of battery storage across California that is expected to be online by 2024.[122] However, it should be noted that the large scale deployment of batteries in the Pacific Northwest will need to be better understood due to the less regular weather patterns of the region compared to the Pacific Southwest.

Current battery technology is limited to provide peaking support continuously over multiple days like the hydrosystem, to address prolonged winter cold snaps or summer heat events. Furthermore, batteries add to system load when charging and will require substantial raw materials for their production. Future developments in energy storage technology are expected to alleviate some of these issues, mainly through the ability to peak for longer durations.

Hydrogen technology is another emerging energy source with a variety of applications that could assist with the transition towards a decarbonized future. Hydrogen can be utilized to reduce carbon emissions in the transportation sector with the use of hydrogen fuel cell electric vehicles, as feedstocks for industry, such as ammonia production and metals refining, heat for buildings, and energy storage.[123] While hydrogen is abundant in our environment and can be found in water, methane, and other organic matter, it is challenging to efficiently extract hydrogen from these sources. Steam reforming, a process of combining high-temperature steam with gas to extract hydrogen, accounts for the majority of hydrogen production in the United States.[124] However, hydrogen that is produced through steam reforming does not result in any reduction in greenhouse gases compared to using gas directly. Hydrogen can also be produced via electrolysis, a method by which an electric current splits water into hydrogen and oxygen. If the electricity used for electrolysis is from renewable sources, the resulting hydrogen would be considered renewable too.[125] The 2021 Washington State Energy Strategy identified electrolysis as a key component for reaching the state's clean energy goals, as it could help balance the region's short-term surpluses of renewable generation, which could in turn replace the use of fossil fuels in transportation and industry.[84] The addition of green hydrogen production at this scale for uses both within and outside of Washington will require a substantial increase in renewable generating capacity that is currently beyond what is anticipated to meet existing end uses.

There are several efforts in Washington to use hydrogen as an energy source. For example, Douglas County PUD is developing a pilot hydrogen production facility, Seattle City Light is exploring the use of hydrogen fuel cells for their medium and heavy-duty vehicles, and Lewis County recently received funds to develop a "hydrogen valley" in Centralia and Chehalis that will both create hydrogen energy and facilitate the creation of Washington's hydrogen energy market. [126, 127, 128] Additionally, the Washington State Legislature has enacted multiple pieces of legislation to encourage and guide the development and use of green hydrogen production with the Renewable

† The following link from CAISO provides an overview of how they are using the technology and their future plans: http://www.caiso.com/about/Pages/Blog/Posts/New-video-on-historic-growth-of-battery-storage-released.aspx.

Hydrogen (Chapter 292, Laws of 2022 - SB 5910 & the Supplemental Transportation budget (Chapter 186, Laws of 2022, ESSB 5689), as well as multiple tax exemption and grant programs.[129]

Another resource the Pacific Northwest has been actively investing in is demand response, which the NWPCC defines as "a non-persistent intentional change in net electricity usage by end-use customers from normal consumptive patterns in response to a request on behalf of, or by, a power and/or distribution/ transmission system operator. This change is driven by an agreement, potentially financial, or tariff between two or more participating parties."[99] In layman's terms, demand response is the voluntary and temporary reduction or shift in consumers' use of electricity in response to specific system conditions or price signals. Demand response programs and products, like demand voltage regulation and time-of-use rates, can help the region meet loads during peak times.[99] The NWPCC recognizes that demand response is capable of providing energy, capacity and ancillary services while also acting as a replacement of new resources.[130] However, only a portion of this resource may be available for LSRD replacement, as the lowest cost forms of the resource are being actively adopted to help Northwest utilities meet other challenges.

Another significant resource that the region has continued to rely on is energy efficiency, which is similar to demand response, but is defined as "any reduction in electric power consumption as a result of an increase in the efficiency of energy use, production, or distribution."[131] Energy efficiency is currently the second largest resource utilized by the region, second only to hydropower, and according to the NWPCC 2021 Power Plan, since 1980 has resulted in $4 billion in consumer electric bill savings as well as avoided 25 MMT of CO_2 emissions.[131] The NWPCC recommends that the region acquire at least 750 aMW of the resource by 2027 and at least 2,400 aMW by 2042 through ratepayer funded programs, researching emerging energy efficiency technologies at levels equal to or greater than 2020 levels, continuing market research and related analysis, and supporting initiatives to enhance building codes and appliance standards at the state and federal level.[99] While recent developments in wind and solar technologies have become competitive with energy efficiency measures in terms of cost, it will be through the efficient management of all of these low cost resources, i.e., demand response, energy efficiency, new renewables, and hydropower, to ensure that the region is meeting its future energy needs with a reliable and economical power supply.[99]

As the cost of onshore wind energy development has fallen, so has the cost of developing offshore wind farms.[118] Offshore wind resources are abundant, stronger and more consistent than land-based wind resources.[132] While most offshore wind development has occurred on the East Coast of the U.S,[133] the U.S. Department of Energy's Wind Energy Technology Office has identified the potential of 2,000GW in annual capacity from the resource in state and federal waters.[132] In 2021, Oregon and California each passed legislation that lays the groundwork for their respective state to develop offshore wind programs.[134] In Washington, plans for the first offshore wind farm off the Olympic Peninsula were proposed in 2022.[135]

Another proposed technology is the use of small modular nuclear reactors, which are currently in development but have not been utilized on a utility scale. Small modular nuclear reactors also have associated siting and environmental challenges.

Finally, another potentially helpful technology is the use of pumped storage reservoirs. Pumped storage reservoirs utilize surplus power from either wind or solar to pump water into a storage reservoir, to then be utilized later when other generation sources are insufficient to meet load.

Similar to the development of solar and wind projects, pumped storage projects will need to address siting and environmental issues. Additionally, pumped storage facilities are limited in the locations that they can be sited due to the need to construct both an upper and lower reservoir.

Some of the technologies mentioned above may be available as alternatives to meet future energy demand if the LSRD were to be breached, but it is not certain which ones and there are differences of opinion amongst energy experts about when they will be commercially available. Regardless, these technologies are expected and needed to play a significant role in addressing the future needs of the Pacific Northwest Energy System as the region moves towards decarbonization and responds to climate change.

Market development and integration of the West Coast power system

As the energy sector has become more advanced, the Pacific Northwest and the larger West Coast energy grids have become more integrated. This grid integration has created new power markets for the sale of surplus energy between entities, which can incentivize better dispatch of generation resources for the benefit of all parties involved and allow for additions of renewable generation and non-emitting resources to serve energy and capacity needs. For example, the Western Energy Imbalance Market, which fosters better resource integration and the Western Resource Adequacy Program, which was specifically designed to provide coordinated use of capacity resources to ensure reliability, which BPA was a part of the development of, but has not made a decision to officially join. However, this increased market development and integration does not create new capacity or affect the resource adequacy of BPA. If the LSRD were to be breached the expected regional capacity in the Western Resource Adequacy Program would be negatively affected since the dams can represent as much as 5% of the program's capacity in some months. Under the terms of the program, this loss would necessitate additional actions or acquisitions to mitigate the increased blackout risk. Moving forward the NWPCC anticipates that wholesale market prices of energy will continue to fall as renewable generation expands in the Western U.S., and projects that mid-term and long-term market purchases will be the low-cost resource alternative beyond recommended energy efficiency and demand response resources.[99]

Columbia River Treaty

Another facet of the Columbia Basin hydroelectric system that could change in the near future is the Columbia River Treaty. The Columbia River Treaty with Canada is the governing document for the operation of the Columbia Basin hydroelectric system and was initially agreed upon in 1964 as a 60-year agreement.[136] The terms of a post 2024 agreement are currently being negotiated including elements of flood control and energy supply and a potential additional principle associated with ecosystem management. Fifteen tribal sovereigns in the U.S. portion of the Columbia Basin would like the United States and Canada to modernize the Columbia River Treaty in ways that restore and maintain ecosystem functions compatible with healthy and harvestable tribal protected resources, while protecting fish impacted by the energy systems of the two countries.[5]

2028 BPA contract renewals and rates

BPA power sales contracts between utilities and BPA are set to expire in 2028. These 20-year agreements operate under BPA's tiered rates methodology, which is updated every two years to allow utilities to purchase power from BPA up to their established contract amount at BPA's Tier 1 rate.[137] The Tier 1 rate is based on the cost of the existing Pacific Northwest region, which takes into account the cost to operate the federal hydrosystem, fish and wildlife costs, federal debt repayments, and other costs related to the administration of the sales of federal power.[138] If a utility's load needs to exceed their contract limit, they may buy more power from BPA at the Tier 2 rate, that reflects the cost of such additional power.[137] Any changes to the cost of generation will impact utilities that utilize BPA for most of their energy, and especially for BPA customer utilities which rely on BPA for all their generation and transmission due to their small size and location.

Any changes to energy resources must consider the energy burden placed on low-income customers and vulnerable populations. Washington state defines excess energy burden or "energy assistance need" as the portion of household energy expenditures, excluding transportation, that exceeds 6% of household income.[139] Washington's CETA charges electric utilities with improving low-income assistance and conservation with an objective to meet 60% of energy assistance need in 2030 and 90% of energy assistance need in 2050.[140] The state's Department of Commerce has published an extract of data from the U.S. Department of Energy Low-Income Energy Affordability Data tool that estimates nearly 11%, or 314,000, of households statewide have annual excess energy burden totaling $334 million[BX].[‡] Any substantial rate increase could be felt twice by consumers - directly on monthly utility bills and indirectly through potential loss of jobs and economic activity in communities where large energy-intensive industrial manufacturers could shift production out of the region rather than absorb the full weight of increased costs.

The renewal of BPA contracts is a primary focus for many of the utilities in the region. Many may be looking to BPA to supply more electricity to meet their growing needs from population growth and address changes in demand due to climate change and decarbonization of the energy, transportation and building systems sectors. How BPA responds to the changing needs of utilities and changing sources of energy production and transmission requirements will have significant implications for several decades because these contracts can be rigid, not allowing BPA to quickly adapt to the changing energy environment. Uncertainty about the future of the LSRD will be a factor in the renewal process in regard to whether it will continue to be a source to support demand from BPA customers and the cost of the energy.

Future changes to hydrosystem energy generation

Additional changes to hydrosystem management may be needed to further reduce impacts to salmon and other aquatic species. Over the past 20 years, litigation surrounding the LSRD has caused changes in the operation of the dams. This has primarily been associated with additional spill, which constrains the proportion of water available for the turbines, but also includes limitations on reservoir elevation fluctuations and the ponding of water used for power load-following. Spill passes water from a dam reservoir through spillways as opposed to through the powerhouses. Juvenile salmon experience less mortality and better overall survival when they move through spillways as opposed to powerhouses. Spill reduces the amount of water utilized for generation and limits the amount that reservoirs can fluctuate to assist with load following. If dam breaching is not pursued

‡ The excess burden today may be even higher, as energy prices have increased at a higher rate than incomes (St. Louis Federal Reserve, 2022; St. Louis Federal Reserve, 2022)

and salmon populations continue to decline additional court decisions could further limit the operation of the dams.

If litigation and court decision required operation changes similar to alternative MO4 in the 2020 CRSO EIS, "hydropower generation across the Columbia system could decrease by 1,300 aMW under average water conditions, and 870 aMW under low water conditions compared to the No Action Alternative, the largest impacts on hydropower generation of any of the alternatives considered in the EIS. The primary reason for the reduced generation is the increase in juvenile fish passage spill, up to 125% total dissolved gas levels 7 days a week, 24 hours a day from March 1 to August 31, with most lower Snake and lower Columbia River projects operating at minimum generation levels in the majority of water conditions. This increase in spill, together with a measure that provides dry-year augmentation of spring flow with water stored in upper basin reservoirs, contributes to MO4 having the highest probability of power shortages of any of the EIS alternatives, with blackouts or emergency conditions in roughly one in three years (pg. 35)."[9]

Further, recently settled litigation to address water temperature for the benefit of in-river species has led to newer regulatory requirements including the Environmental Protection Agency's 2020 Columbia and Lower Snake Rivers Temperature Total Maximum Daily Load (TMDL), National Pollutant Discharge Elimination System (NPDES) permits, and Section 401 water quality certifications issued to dam operators in April 2022. The recent trend toward reduced summer and fall flows for the LSRD due to increased drought and reduced snowpack puts further constraints on river operations and the power and capacity functions of the dams. In total, all three of these constraints; spill for the benefit of salmon, mandates on in-river water temperatures, and lower flows due to drought and reduced snowpack all threaten current and future hydropower operations for the LSRD, which in turn reduces the ability for these dams to produce peak generation levels and have sufficient flows to achieve these sustained peaks.

The temperature TMDL requires all the dams on the Columbia and Snake River systems to collectively reduce their heat load to 0.3°C, significantly less than they are currently adding. The new NPDES permits for the four lower Snake River dams, along with the 401 certifications, newly require the operators of the dams to meet state water quality standards and the TMDL heat load requirements. Washington state is now working with the Corps on how they will comply with these new requirements to reduce the heat loading caused by current dam operations. This will require consideration of all reasonable and feasible improvements that could be used to meet the load allocation along with a plan and benchmarks for implementing those actions.

Actions needed to replace or improve services

Introduction

The issues described above illustrate the complexity of the challenges and opportunities for replacing the energy benefits of the LSRD. Replacing the energy production as well as the ancillary services provided by the LSRD is possible. However, to do so will take time, require significant funding for the construction of alternatives, and the region will have to successfully address a number of issues including siting, the regulatory environment and ownership. Replacement of the LSRD energy production with renewable, carbon-free sources is a small percentage of the regional need forecast for 2050 but adds to the challenge. Additionally, continued advancement of battery technology is necessary to address the future dispatchable needs of the Pacific Northwest region, which many industry experts believe is likely in the coming years.

There have been several analyses for replacing the power attributes of the LSRD. However, it should be noted that the portfolio that is ultimately decided upon will most likely differ in its composition once additional optimization and reliability studies are conducted. If the LSRD were to be breached, the replacement portfolio needs to be in place and demonstrating that it is producing energy and providing services to the grid before the dams were breached. If the replacement portfolio is not in place, the Pacific Northwest region would experience increased challenges. These include the reduction in peaking capacity, risk of congested transmission lines particularly near the Tri-Cities, increased power rates, and potential increases in carbon emissions due to increased emitting generation to compensate for the loss in capacity. However, if the alternatives for replacing the power are operating before breaching occurred, these impacts are not likely. As mentioned previously, the replacement portfolio does not necessarily need to be a one-to-one replacement of the current services provided by the LSRD. Some experts believe that the guiding principle should be an optimized portfolio that will better meet the future needs of the broader energy system year-round. Other experts believe that anything less than a one-to-one replacement will create rate impacts for Northwest customers, reliability impacts for the grid, and increase GHG emissions.

Updated costs of replacement portfolios

In this section, due to uncertainty in current and future costs to construct and operate power generation facilities, costs to construct replacement power resources are noted in the original dollar values projected in the source studies. Costs to construct gas generation facilities are also presented in 2022 dollars, assuming that gas generation facility construction from the year of the source document to the present has increased by the same percentage as general construction costs have risen (i.e., we use a general construction cost index to inflate). For renewable energy generation costs, considering a) the long-term trend of decreased costs to construct renewables, b) recent high increases in general construction costs, and c) the fact that the most recent data available on construction costs specific to energy technologies are from 2020 and not 2022, we do the following: for capital costs of renewables we do not adjust the low end cost estimates for inflation but leave them in the original source dollars, and for the high end cost estimates we adjust values to 2022 dollars from the original source dollar year using a general construction cost index. These costs are intended to provide a general approximation of potential costs in 2022 dollars; further study is warranted to provide a more refined estimate of replacement portfolio costs. Finally, when we convert annualized average costs from the available studies, we assume that annualized costs will be constant over the 50-year study period. Given the recent history of cost declines for renewable energy resources, and the projected future decline in renewable energy costs, the 50-year costs presented in this report may be an overestimate of total power replacement costs that may be incurred over that time horizon.

Proposed replacement portfolios for annual and peaking energy

Currently, the four main studies that define LSRD replacement portfolios are the 2022 BPA Lower Snake River Dams Power Replacement Study developed by Energy+Environmental Economics (E3), the 2020 CRSO EIS, the 2018 Northwest Energy Coalition (NWEC) Lower Snake River

Dams Replacement Study and the 2022 Lower Snake River Dam Replacement Update (Energy Strategies).[86, 141, 142] The two main portfolios in the NWEC report that can be compared to the portfolios in the CRSO EIS are the Gas Only and Balanced Plus replacement portfolios, which are similarly structured to the Conventional Energy and Zero-Carbon portfolios in the 2020 CRSO EIS.[86, 108] The 2022 Energy Strategies study updated the 2018 NWEC study costs and refined an option for optimizing the replacement to better meet the needs of the Pacific Northwest region. Other studies have also looked at replacement of the LSRD within the context of meeting future load needs within the rapidly changing energy environment. In 2017 and 2019 the consulting firm E3 developed two reports: Pacific Northwest Low Carbon Scenario Analysis and Capacity Needs of the Pacific Northwest 2019 to 2030. [143, 144] Both reports came to similar conclusions on the difficulty and rapidly increasing costs associated with reaching full decarbonization. The 2019 report found that in order to reach 80% emission free generation by 2050 the additional investment cost would be $1 billion to $4 billion (potentially $1 billion to $4.7 billion in 2022 dollars)[BY] compared to 2018 investment levels, with the cost jumping to $16 billion to $28 billion (potentially $16 billion to $33 billion in 2022 dollars)[U] to reach 100%.[144] Another major finding from these reports was that due to the projected retirement of coal-fired generation, they projected that the Pacific Northwest will have a 3,000MW shortfall in capacity by 2030.[145] In contrast, NWEC views when utility plans are factored in to replace these retiring resources as well as market purchases, the projected capacity shortfall for 2030 is only 1,000MW, which is in line with energy efficiency and demand response resource acquisitions that the NWPCC requested the region to acquire (Idaho Conservation League and Northwest Energy Coalition, pers. comm., May 3, 2022). Between these resource portfolios, there are many combinations which could be optimized with other resources.

Both the 2020 CRSO EIS Conventional Energy and the NWEC Gas Only replacement portfolios would utilize gas generation sources to replace the energy production provided by the LSRD. In total, the NWEC Gas Only replacement portfolio was estimated to cost $535 million annually in 2018 dollars[86] (potentially $629 million annually in 2022 dollars, or $18.8 billion in present value cost over 50 years assuming no change in real dollar costs of generation over the 50 year time horizon[BZ]) and the 2020 CRSO EIS Conventional Energy replacement portfolio was estimated to cost between $270 million annually in 2019 dollars, or potentially $311 million annually in 2022 dollars[CA] ($9.3 billion in present value costs over 50 years assuming no change in real dollars costs of generation over that time horizon.)[108] However, as was previously mentioned, with recent regulatory developments in Washington and Oregon, the ability to leverage gas burning generation is most likely very limited.

Alternatively, the energy generated by the LSRD could be replaced by a clean energy portfolio that would rely on increased solar and wind generation, energy storage, energy efficiency, and demand response. The 2020 CRSO EIS Zero-Carbon portfolio includes solar generation in eastern Oregon as well as demand response in Seattle, Spokane and Portland to replace the energy production and services provided by the LSRD.[9] The 2020 CRSO EIS forecasts that this replacement portfolio would lead to a 6.6% loss of load probability (LOLP).[108] LOLP is a system reliability measure utilized by the NWPCC that captures the probability of a loss of load event happening within a given year, i.e., an event where utilities have to shed load or take other undesirable emergency actions occurring within the Pacific Northwest region. The NWEC Balanced Plus replacement portfolio outlines wind generation, solar generation, demand response and energy efficiency resources to replace the energy production and services provided by the LSRD.[86] NWEC forecasts that this replacement portfolio would result in a LOLP of approximately 2%. While both sources utilized the same model (NWPCC GENESYS) for determining the projected system reliability, the 2020 CRSO EIS forecasts that due to the location of the newly constructed renewables these resources will not be able to provide the same levels of reliability as the LSRD.

Both the NWEC Balanced Plus and 2020 CRSO EIS Zero-Carbon portfolios estimate that the fixed costs for these portfolios could cost $400 million annually in 2019 dollars for just the replacement resources, which in 2022 dollars may be approximately $400 million to $461 million[CB] annually. In total, the NWEC Balanced Plus portfolio was projected to cost $464 million[CC] annually in 2017 dollars, which may be approximately $464 million to $562 million annually in 2022 dollars, equating to $13.8 billion to $16.8 billion in present value costs over 50 years assuming no change in real dollar costs of generation over this time horizon.[108] The CRSO EIS Zero Carbon portfolio was expected to cost $540 million annually in 2019 dollars (based on the EIS analysis of changes in production costs and associated changes in social welfare), which may be approximately $540 million to $622 million annually in 2022 dollars[CD] or approximately $16.1 billion to $18.6 billion in present value cost over 50 years assuming no change in real dollar costs over this time horizon.[86]

The 2022 Energy Strategies analysis provides a new estimate for LSRD energy replacement based on current costs and several different, optimized portfolios. This analysis found that a replacement portfolio that includes a combination of wind, solar, and energy storage would cost between $362 million and $441 million[CE] annually.[142] The higher end of this cost estimate represents a one-to-one replacement portfolio of the average generation output of the LSRD, which has additional solar to provide generation equivalent to the LSRD in spring, when the dams generate most of their energy. Additionally, this study suggests that the replacement portfolios could provide an additional $85 million to $131 million[CE] per year in additional energy value than what the LSRD currently provide.[142] This would be achieved by producing additional power outside of the spring runoff period when the LSRD currently have their highest output, but the region is also at its highest generation levels at the other dams in the federal hydrosystem. With this additional benefit compared to current operations, the study found that these identified replacement portfolios would have a net replacement cost of between $277 million and $311 million[CE] on an annualized basis, or a present value cost of $8.3 billion to $9.2 billion over 50 years assuming no change in real dollar costs of generation over this time horizon [142] As was mentioned previously, and was reinforced by this study, the peaking capabilities of the LSRD are the hardest to replace with existing technologies. However, this study suggests that 100% replacement of this capability may not be necessary or cost effective because there could be additional peaking capabilities already within the existing infrastructure.[142] The portfolios analyzed by Energy Strategies relied on projects already in the BPA transmission interconnection queue that were not speculative and could be implemented by 2028 at the latest. These portfolios required only 12% of the total projects in the BPA queue to replace the energy services from the LSRD.

NWEC cited that at least three major regional utilities have recently issued RFPs for the construction of additional clean, renewable generation and storage to meet peak and energy needs that the utilities want to be in place and operating by 2025.[142] The scale of these requests for projects are generally comparable to replacement of the LSRD. In each instance these utilities have received bids from developers for four to eight times the amount of additional power they sought.

The new E3 2022 BPA Lower Snake River Dams Power Replacement report, which was conducted for BPA, estimated the cost of replacing the power provided by the LSRD based on the need to replace 3.5 GW of total capacity and 2.3 GW of firm peaking capacity. This report found replacing the LSRD while meeting clean energy goals and system reliability is possible but comes at a substantial cost, assuming emerging technologies are available.[86] The study used a proprietary model to estimate the optimal capacity needs of the Northwest region and estimates the costs of meeting those capacity needs both with and without the LSRD, while also minimizing costs, ensuring resource adequacy, and operational reliability. E3 modeled the costs under both the with- and without-LSRD scenarios, and the difference in costs between these scenarios was presented as the additional cost of removing the LSRD. Assuming that replacement resource portfolios could rely on emerging technologies not yet commercially viable, such as hydrogen combustion turbines and advanced nuclear reactors, the study estimated that removing the LSRD would result in annual cost increases in 2022 dollars of $415 million to $496 million in 2035, rising to $428 million to $860 million in 2045. These annual cost increases have a present value in the year of dam removal of $13.0 billion to $22.7 billion[DB] over 50 years. However, relying solely on existing technologies with no new combustion generation, and assuming no technological breakthroughs, the study estimated that the annual cost increases could range from $1.0 billion to $3.2 billion annually, with a present value of costs of $49 billion to $89 billion.[DC] This high-end cost estimate is based upon a replacement portfolio with only intermittent resources like wind, solar, and short-term battery storage to replace the full capacity of the LSRD, and is not seen as a viable path for the region. It is the view of both Senator Murray and Governor Inslee that this type of replacement portfolio is not valid and that with the significant investments the region has made in both hydrogen and small nuclear reactor technology that these emerging technologies will be available for replacing the capacity of the LSRD.

E3 identified that the biggest cost drivers for replacement resources are the need to replace the lost firm capacity for regional resource adequacy and the need to replace the lost zero-carbon energy. Replacement becomes more costly over time due to increasingly stringent clean energy standards and electrification-driven load growth. Emerging technologies such as hydrogen, advanced nuclear, and carbon capture can limit the cost of replacement resources to meet a zero emissions electric system, but the pace of their commercialization is not certain.

The recently released 2022 Lower Snake River Dams Power Supply Replacement Analysis developed by Energy GPS for Northwest RiverPartners examines the replacement of the LSRD from a different perspective.[121] Factoring in decarbonization laws within the region, this report examined what the necessary build out of new carbon-free resources would be to reach a decarbonized grid both with and without the LSRD. In comparison to the E3 analysis of replacing 3.5 GW of total capacity, this study estimated that removing the LSRD would require 14.9 GW of additional solar, wind, and storage, as it assumes that "to fulfill clean energy mandates, renewables and storage are built to replace the loss of the LSRD peak capacity, but due to curtailments, only 9% to 12% of the new resources can be utilized to meet demand (pg. 3)".[121] With these assumptions, the Energy GPS study estimated the additional present value cost of meeting clean energy requirements without the LSRD, i.e., difference in cost without the LSRD compared to with the LSRD, at approximately $14.7 billion[DD] over a 16-year time period from 2030 to 2045, with annual recurring costs reaching $2.5 billion in 2045. It is unclear if this value of $2.5 billion is in 2022 or 2045 dollars. If it is in 2045 dollars, it would be equivalent to approximately $1.6 billion in 2022 dollars based on the study noting the use of a 2% annual inflation rate. [DE] Assuming average annual costs of $1.6 billion to $2.5 billion were to continue over the remaining years in a 50-year time horizon, then the 50-year present value of costs would be approximately $41.5 billion to $56.9 billion.[DF]

Replacing annual energy production

If the LSRD were to be breached, the Pacific Northwest Energy System would need to replace 900 aMW of non-emitting energy. [19] As discussed, this annual generation could be replaced by other carbon-free sources of generation like wind or solar. In the 2020 CRSO EIS, if the annual energy provided by the LSRD were to be replaced by these energy sources the probability of a LOLP is expected to be 6.6%.[108]

Replacing peaking capacity

If the LSRD were to be breached the Pacific Northwest region would need to replace the peaking capacity provided by the dams and utilize existing and advancing technologies. Battery storage, primarily with Lithium-Ion Batteries, is currently the main source of carbon-free capacity that is being utilized at scale within other areas of the United States. Industry experts believe that future battery technologies that provide larger storage capacities will provide longer peaking capacity. Alternatively, small modular nuclear reactors have been suggested for replacing the zero-carbon peaking capacity the LSRD currently provide, though the technology is not yet commercially available. Recent findings from E3 have found that battery storage technologies are limited in their ability to replace hydropower capacity in the Northwest due to the nature of when capacity shortfalls typically occur in the region during times of low hydro and renewable output that limits the ability of batteries to recharge to provide capacity for extended multiple day events.[86] Battery storage capabilities are better suited for the Pacific Southwest as opposed to the Pacific Northwest because the Southwest has a more regular diurnal wind and solar regime that allows batteries to recharge.[86]

Another resource that could be utilized to reduce the future peaking needs of the Pacific Northwest region is the use of demand response, otherwise known as conservation, the NWPCC estimates that demand response programs and policies could reduce summer loads by 3,721 MW and winter loads by 2,761 MW, but it is not clear how much of this potential would be available, appropriate, or cost effective for replacement purposes.[99]

Maintaining grid resiliency and transmission services

If the LSRD were to be breached there are differing opinions on the amount and cost of additional short- and long-range transmission lines necessary to integrate the replacement portfolio into the grid. Some of the reports included these costs within their cost estimates, while others did not project these costs.

The 2022 Energy Strategies study did not identify the need for substantive, additional transmission capacity or other system upgrades for their optimized alternative for replacement, so this analysis was not performed; the study did not include grid connection costs, which the authors expect to be small. Energy Strategies also did not include costs of demand response or power purchases. This is similar to the 2022 Energy GPS study that did not evaluate the cost of building long-distance, high voltage transmission lines or the risks associated with land-use and siting for renewable resource development. Additionally, within the Energy GPS study the availability of new transmission to support the necessary renewable build out to achieve decarbonization was captured via a cost addition to incremental new wind units only, with the study noting that major new transmission that is likely needed was not captured in the model, and thus costs are likely to be higher. The 2022 E3 study captured the costs of new transmission upgrades necessary for each of the selected replacement resources utilized within each scenario within their renewable energy supply curves. Their findings varied on the resource type with some resources requiring extensive transmission upgrades. This study did not model additional reliability services the LSRD provide to the grid, and the study expects that the replacement of transmission services can be achieved either through siting and operations of the incremental replacement capacity selected or by additional local transmission investments. The study noted that the scale of these transmission investments requires more detailed study.

The 2020 CRSO EIS identified that prior to evaluating the effects of a potential breach of Ice Harbor Dam BPA had identified the need for a transmission reinforcement project just beyond the 10-year planning horizon to maintain reliable load service to the Tri-Cities area. The base need for the project would arise independent of removal of the generation at Ice Harbor.[108] The timing of the reinforcement, however, is very dependent upon when Ice Harbor generation might be removed. The scope of the likely reinforcement would include a new substation, a new 20-mile-long transmission line, and the expansion of an existing substation near the Tri-Cities. The reinforcement project would cost approximately $109 million[AR] in direct costs to construct.[108] Additionally, the 2020 CRSO EIS identified the cost for upgrading and adding additional transmission to accommodate the additional replacement resources at $167 million[CJ], bringing the total cost of the project to $276 million; these transmission and reinforcement costs are included above in the annualized replacement costs for the CRSO EIS Zero-Carbon and Conventional Energy portfolios.[108]

Maintaining low energy rates

If the LSRD were breached, and the energy provided by the dams is replaced by other alternative sources, power costs could increase depending on if BPA, regional utilities, or the federal government will be funding the replacement portfolio for the LSRD. Figure 20 shows the projected rate increases for the Zero-Carbon Portfolio in the 2020 CRSO EIS under two financing scenarios.[108] The left map illustrates projected rate increases if BPA and its customers fund and build out the replacement resources, while the right map illustrates projected rate increases if replacement resources are funded and built out by regional utilities.

Under both scenarios the 2020 CRSO EIS anticipates that rates will increase across the entire Pacific Northwest region, with higher anticipated rate increases for areas that rely more on BPA for both generation and transmission. Power experts interviewed for this report noted that the magnitude of rate increases is correlated with the cost of the ultimate replacement portfolio, minus the decrease in costs for operating and maintaining the LSRD, with increased cost of replacement leading to increased power rates. According to Tacoma Power, if the replacement costs are funded by ratepayers, projected rate increases range from 10% if the replacement portfolio costs approximately $10 billion[G], to over 25% if the replacement portfolio costs approximately $20 billion (Tacoma Power, pers. comm., April 20, 2022). About 50% of electric customer load in Washington State is served by BPA. The CRSO EIS found the expected impact for BPA customers would increase electric rates by 9.3% to 21.6%.[108] This figure represents the cost impact if fossil fuel resources were utilized as replacement resources; the cost would most likely be higher if carbon-free resources are chosen for replacement. Note that these replacement portfolios assume a one-to-one replacement of LSRD services as opposed to a portfolio that optimizes the broader energy system to meet needs. In order to avoid these rate increases most, if not all, of the funding for these replacement resources will need to come from the federal government supported by the nation's taxpayers, in contrast to utility ratepayers.

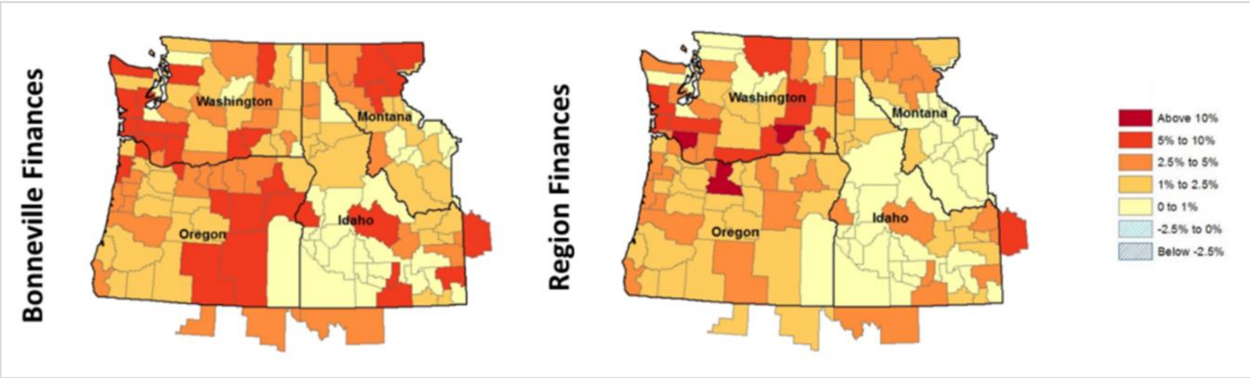

Figure 20: Projected rate increases for the zero-carbon portfolio under two scenarios across the BPA service area.[108]

In the recent E3 study, the cost increases due to the replacement resources for the LSRD translate to 8% to 18% growth in BPA's public power customers costs in most of the scenarios, and public power households would see an increase in annual electricity costs of $100 to $230 per year in 2045.

Additional factors that will need to be determined

To replace the annual energy contribution and peaking capacity of the LSRD, several factors will need to be addressed. A decision would need to be made on who will act as lead in determining the replacement portfolio as well as conducting all the necessary regulatory actions to construct and integrate the replacement portfolio. Another factor that needs to be addressed is who pays for the replacement portfolio, regional ratepayers or the federal government, i.e., the nation's taxpayers.

If the cost of the replacement portfolio falls on regional ratepayers, this would likely lead to rate increases across BPA customers and could run counter to the provisions within CETA that require the energy burden is reduced for low-income customers. The responsible party or parties for the replacement portfolio will play a large role in determining the location of these replacement resources and need to navigate a variety of regulatory and integration challenges depending on location.

Actions needed to replace or improve the benefits

With technological improvement, significant investment, and sufficient time, replacing the energy production as well as the ancillary benefits provided by the LSRD may be possible. However, it will take time, funding, planning and collaboration across all stakeholders to ensure that the region's future clean energy goals are met, the region maintains a reliable system, and customers, especially the most vulnerable, are not overly burdened by increased electricity rates. The replacement portfolio should be in place and demonstrating that it is producing energy and providing services to the grid before breaching occurs to avoid significant impacts to the regional energy system and the communities it serves. Additionally, the replacement portfolio for the LSRD does not need to be a one-to-one replacement of what the LSRD currently produce, as this may not be the most economically prudent course of action if a replacement portfolio would be better suited to be optimized to meet the future energy needs of the broader Pacific Northwest region. Below is a summary of the actions and factors that need to be addressed to replace or improve upon the existing energy benefits provided by the LSRD.

- **Lead agency:** Determine what agency will act as lead in determining the replacement portfolio as well as conducting all the necessary regulatory actions to construct and integrate the replacement portfolio.
- **Replacement portfolio**: Develop a detailed plan for an optimized replacement portfolio that can address additional increment to forecasted future needs, reduce and avoid impacts to salmon and address environmental and cultural sites.
- **Technological advancements**: Determine how technological advances in storage, energy production and demand response can most efficiently address issues like annual energy production, peaking capacity, dispatchability, grid resiliency and transmission services.
- **Funding**: Determine what entity will be required to pay for the replacement portfolio and determine the location of any replacement resource.
- **Implementation**: Implement the plan including energy generation and transmission.

Estimated total energy replacement costs

There are a variety of replacement portfolios proposed to replace the energy and grid services provided by the LSRD. Table 16 summarizes these replacement portfolio costs in terms of both annual and total costs. The total cost of the replacement portfolio within each report varies greatly due to number of factors, including: the generation technologies in the replacement portfolio (and associated carbon intensity), estimated future cost to construct the replacement portfolio (which for low carbon portfolios depends on the assumed change in the future cost of renewables), estimated future natural gas fuel costs, the desired output and reliability of the resource portfolio (one-to-one replacement vs. system optimization), siting considerations, and projected additional transmission needs, assumed construction year of replacement resources and assumptions of the cost of replacement generation at the time of construction. Within the CRSO EIS cost estimates include, "a contingency of 50 percent was added to all construction estimates. Based on historic Corps cost engineering estimates, 30 percent of the construction and contingency cost was included to account for supervision, administration, and engineering during construction."[21] However, the portfolio that is ultimately decided upon will most likely differ in its composition once additional optimization and reliability studies are conducted. In addition to the estimates in the table, transmission upgrades for Tri-Cities would cost approximately $109 million in direct costs to construct in addition to the additional incremental costs of new transmission.[108]

The costs over 50 years presented in Table 16 assume that the annualized costs estimated in the source studies are applicable for 50 years (i.e., that operations, maintenance, and replacement costs of resources in future years do not change but are the same in real dollar terms as those estimated in the source studies). The capital costs of constructing renewable resources have been declining historically; if these costs continue to decline, the costs over 50 years of renewable energy portfolios would be lower than provided in the table.

Table 16: Summary of estimated energy replacement costs.

Source	Estimated 50 Year Cost of Replacement Resources	Notes
CRSO EIS (2020)	$9.3 billion to $18.6 billion	The low-cost estimate is for the Least Cost portfolio and the high-cost estimate is for the Zero Carbon Portfolio. Includes capital and operating costs, transmission upgrades, and demand response
Energy Strategies (2022)	$8.3 billion to $9.3 billion	The low-cost estimate is for the BPA Net Position portfolio and the high-cost estimate is for the BPA Load Shape portfolio. Includes capital and operating costs of renewable energy portfolios. Does not include transmission upgrades, grid connection costs, or other system upgrades (anticipated by the authors to be small)
E3 (2022)	$13.0 billion to $22.7 billion	The low-cost estimate is for the Scenario 1a portfolio and the high-cost estimate is for the Scenario 2a portfolio Costs represent those required for firm capacity power replacement Includes transmission costs The low-end value assumes emerging technologies become commercially viable. The report also includes a high-cost estimate of $49 billion to $89 billion. These high-end values assume no combustion resources and no technological breakthroughs for emerging technologies, and high increased electricity loads due to increased electrification.
Energy GPS (2022)	$41.5 billion to $56.9 billion	Costs represent the cost of constructing 14.9 GW of name plate resources due to assumed low effective capacity rates that only 9% to 12% of the new resources can be utilized to meet demand. Does not include costs for transmission, increased electrification, or land use/permitting of new infrastructure, or emergence of new technologies. The Energy GPS report estimates $15 billion costs from 2030 to 2045 with annual recurring costs of $2.5 billion from 2046 to 2080 for replacing the energy of the lower Snake River Dams. The present value cost range of $41.5 billion to $56.9 billion reported is reflective of the way dollar values are presented throughout this report, i.e., a 50-year time horizon and the federal water resources planning rate of 2.25%
Simpson Proposal (2021)	$16 billion	Includes "Clean Firm Power Replacement", "Salmon Spill" replacement power, NW Grid Resiliency and Optimization

9. Tourism and Recreation

Overview

The reservoirs, dams, and shorelines of the reservoirs on the lower Snake River provide land- and water-based recreational opportunities and access. The current reservoir system allows for large river cruise boats that bring tourists from Astoria, Oregon up the Snake River to Clarkston, Washington, transporting approximately 18,000 passengers annually.[20] Over the past 20 years the cruise boat industry has grown substantially, and this growth is expected to continue.

If the LSRD were breached the river will shift from a series of flat-water reservoirs to a free-flowing river. The shift to a free-flowing river would result in the loss of some current recreational opportunities and create the potential for growth of new recreational opportunities. Cruise boat navigation between Tri-Cities and Lewiston-Clarkston would no longer be possible if breaching were to occur. Cruise activity could continue on the lower Columbia River, but these cruises would terminate their upriver journey in Tri-Cities. Some of the other existing activities that currently occur on reservoirs—like fishing, boating, and wildlife opportunities—could continue with a free-flowing river.

While some recreation opportunities reliant on flatwater reservoirs would be lost with dam breaching, new recreation opportunities associated with a free-flowing river could be realized. New opportunities for trails, campgrounds and other recreation-based infrastructure could connect the communities surrounding the LSRD, and recreational, sportfishing and mountain biking opportunities would also have the potential to grow significantly with a free-flowing river. For example, breaching the LSRD could enable growth of the local rafting, canoeing, kayaking and other boating industries and associated tourism, such as jet boating tours, which are currently popular in the free-flowing reach of the Snake River upriver of Lower Granite Dam, and the possibility of multi-day rafting trips within more than 60 rapids that would be accessible if the dams were breached.[146]

Significant investment for recreational facilities and compensation for impacted industries would support maintenance of recreational access for Lewis-Clark Valley communities and develop new recreational opportunities consistent with a free-flowing river. To date, no formal economic analyses have been completed to estimate the total need, cost, and funding sources for potential replacement, modification and expansion of trails, parks, and other recreational facilities if the dams were breached. Similarly, formal cost estimates have not been developed on the need to potentially compensate any adversely impacted sport fishers, boaters, and marinas, and invest in recreation and tourism sectors while the impacted areas transition from flat-water to a free-flowing river. The Simpson Proposal provides preliminary estimates for what a tourism and recreation funding package could look like if the LSRD were breached but did not involve a detailed analysis. It proposes a $425 million[G] investment package for tourism and recreation including development of a national recreation area; tourism promotion resources for Washington and Idaho, sportfishing contingency fund, relocation or compensation for affected marinas and compensation for owners of motorized boats designed for use on lakes.[32] In addition to investments in the region, additional analysis is needed to determine who would manage the newly exposed land after breaching, and for what purposes.

Existing services from LSRD

The reservoirs, dams, and shorelines of the reservoirs on the lower Snake River provide water- and land-based recreational opportunities and access. Water-based activities include fishing, swimming, and boating. Existing water-based recreation facilities, such as boat ramps and swimming beaches, were designed to operate within very specific ranges of water elevations.[19] Land-based recreation includes hiking, camping, and hunting, and many lower Snake River recreation areas have upland facilities such as picnic shelters, concrete walks, and interpretive signs that are located near the existing reservoirs. Although the activities that occur at these facilities are not water-dependent, the proximity of water enhances the recreation experience.

The Army Corps operates, supports, or leases 58 recreational facilities along the lower Snake River, which include visitor centers, parks, boat ramps, fishing sites, campgrounds, and habitat management areas. These facilities provide people with access for fishing, hunting, wildlife viewing, hiking, swimming, and other forms of general outdoor recreation.[19] In 2018, the Army Corps counted 1.7 million visitors to recreation areas associated with the Lower Granite Lake reservoir. The 2020 CRSO EIS notes that "the four lower Snake River projects currently support 0.9 million annual water-based [recreation] visits and 1.7 million land-based [recreation] visits, with a total of 2.6 million annual [recreation] visits overall (pg. M-6-5)."[19] Recreational visits are estimated to support $26.2 million[CK] in value to the recreator above the costs of the recreation experience, i.e., net value to the recreator, for all land- and water-based visitation.[19] From 2017 to 2018, approximately 75% of recreational visits to lower Snake River reservoirs or rivers were to Lower Granite Dam and Lower Granite Lake.[77]

Washington state operates four state parks along the Snake River, including Lyons Ferry, Crow Butte, Central Ferry, and Chief Timothy, which is sometimes referred to as the gateway to Hells Canyon Recreation Area, and three recreation areas are managed by Washington Department of Fish and Wildlife. Local cities, counties and ports also manage and operate numerous parks and recreational sites.

Out-of-area visitors who engage in recreation activities around the LSRD bring out-of-region money directly into the regional economy through spending at restaurants, grocery stores, gas stations, overnight lodging establishments, and on local tourism guides and attractions. Many of the current recreational uses are oriented toward flat water reservoirs created by the dams and access facilitated by Army Corps and state and locally managed facilities.[147]

The current reservoir system allows for large river cruise boats that bring tourists from Astoria, Oregon up the Snake River to Clarkston, WA, transporting approximately 18,000 passengers annually from 2014 to 2019.[20] The cruise ship industry typically operates for 32 to 35 weeks of the year and a ship can move between 100 and 230 passengers each. The biggest draw for cruise boat tourists going to the Lewiston-Clarkston area is to visit Hells Canyon Recreation Area on jet boats. Some cruise ships have operated only up to the Tri-Cities in the past, then bussed passengers to Clarkston to get jet boated to Hells Canyon. However, the bus trip alone is approximately two and a half hours. The 2020 Lewis Clark Valley Cruise Boat Industry report notes that some cruise passengers who do not participate in the jet boat tour can participate in a "Lewis Clark Valley Wine Tour" or a "Hop-On Hop-Off" tour of the area, including Nez Perce National Historical Park, First Territorial Capitol Interpretive Center, Bridablik/Schroeder House, Nez Perce County Historical Society Museum and Visitor Center, and downtown Lewiston.[20]

Over the past 20 years the cruise boat industry has grown substantially, and this growth is expected to continue. In 2018, cruises on the Columbia River outsold the Mississippi River for the first time, and all six operating cruise ships reported being sold out between May and October. As of 2019, seven river cruise ships have dedicated Columbia-Snake River itineraries and cruises account for 2% of all vessels moving through the locks past Lewiston and Clarkston. In the fall, additional cruise ships from Alaska come down to the Columbia River system to operate and serve approximately 1,500 passengers each week. Cruise tourism also contributes to the local economy through tourist spending, and through cruise companies paying tour providers as part of cruise packages, paying port moorage and utilities, and buying provisioning and fuel. Spending by cruise passengers, crew members and cruise lines equaled approximately $3.95 million[CL] in the Lewis-Clark Valley area in 2019 (Figure 21).[20] The estimated total economic output (gross value of all transactions) supported by the industry in the Lewis-Clark Valley in 2019, when considering direct and indirect impacts as well as the multiplier effects, was $4.5 million[W]. Note that this estimate of cruise industry-related spending was not included in the estimate of regional economic effects associated with expenditures on recreation in the basin in the 2020 CRSO EIS.

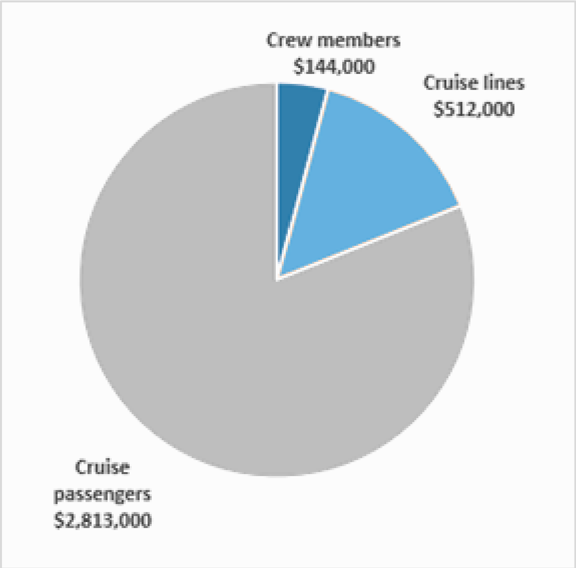

Figure 21: Total spending by cruise industry in the Lewiston-Clarkston region in 2019.[20]

The cruise industry served 19,000 passengers and provided an estimated 70 total (direct, indirect, and induced) jobs to the region in 2019, with a total payroll impact across all sectors of nearly $1.54 million[CS] during the peak visitor season.[20] The Lewis-Clark Valley has seen an increase in cruise traffic and number of vessels in recent years, and should the dams remain, these increases are expected to continue. A 2021 Lewis Clark Valley Cruise Boat Industry Needs Assessment found that despite impacts associated with the COVID-19 pandemic, national river cruise passenger capacity is projected to grow by 80% between 2021 and 2027.[148] American Cruise Lines (ACL) currently operates four vessels on the Columbia-Snake River system, and they have plans to add one additional vessel online from 2023 to 2025, for a total of seven vessels (ACL, pers. comm., May 6, 2022). With seven vessels operating on the river system, ACL expects to bring over 37,000 passengers annually to the Snake and Columbia Rivers. The expected growth of the cruise industry also directly influenced Delta and United airlines to expand service into Lewiston Nez Perce County Airport for 2022.[149] For 2022, the Pacific Northwest Waterways Association provided the following estimates concerning the cruise industry:

- 8,000 visitors flew or will fly to or from the Lewiston, Idaho airport related solely to cruise boat visitation.
- The industry will make 182 cruise stops and serve approximately 25,000 cruise boat passengers.
- Those services will result in a $6 million economic benefit to the region.
- Cruise lines are making significant investments in fleets and are expected to increase the number of vessels navigating up the Snake River in the next few years.

Effects of LSRD removal

If the LSRD were breached the river will shift from a series of flatwater reservoirs to a free-flowing river. The shift to a free-flowing river would result in the loss of some current recreational opportunities and create the potential for growth of new recreational opportunities.

The 2002 EIS evaluated 33 recreational areas that would be affected if the LSRD were breached and found that 11 likely would close entirely because of changes in water levels, two would be closed to river access and 18 would require modifications for river access.[146] For sites with irrigated lawns, if the lawns are maintained new groundwater wells or extended river intakes would be required to ensure continued irrigation and maintenance of the lawn. At least nine marinas or boat moorage sites would be impacted by dam breaching. Some of these impacts are particularly significant. For example, Boyer Park & Marina in Colfax, the only public marina in Whitman County, would likely close in the event of dam breaching. The marina, which lies one mile downstream of Lower Granite Lock and Dam, has invested nearly $6 million in replacing and repairing their docks, a project that is currently underway and received broad support from park users and over $1 million of state funds for both planning and construction (Port of Whitman, pers. comm., February 7, 2022). The 140-acre park green space is highly reliant on irrigation, which would be difficult to continue without the reservoir to draw from. In addition to marina and boat impacts, all current swimming beaches would be eliminated in their current form by changes in water surface elevations (Port of Whitman, pers. comm. February 7. 2022). The 2020 CRSO EIS notes that "lake or flatwater-oriented recreation activities, including water skiing, sailing, motorboating (in fiberglass boats), fishing for some warm-water species…would no longer be possible (pg. 3-1266)."[77] Some local community groups are concerned that a shift away from current recreation opportunities, which are accessible to most people, to those available on a free-flowing river will disproportionately benefit younger, more physically fit individuals and leave out older people and people with disabilities. Ways to address these concerns are under consideration by recreation managers. For example, the theme of the 2023 River Management Society Symposium is "Reimagine River Access," which includes consideration of the physical, economic, and social issues surrounding river access.

If the LSRD were breached, the Army Corps would need to decide whether and to what extent to maintain their role in operating current recreational facilities, versus transferring land management to other entities such as the U.S. Bureau of Land Management (BLM), U.S. Fish and Wildlife Service, National Parks Service, Washington State Parks, or Washington Department of Fish and Wildlife. Regardless of the management entity, dam breaching would require relocation and/or modification of existing facilities and likely construction of new facilities so that water-based recreation could still occur in the region. Any new management structure should also consider the presence of the Lewis and Clark National Historic Trail and other national park units in the landscape. Federal, state and local funding sources are limited and without a dedicated funding source, such as one identified in the Simpson Proposal, land managers and recreational facility operators may not have the capacity to address the costs of revamping facilities and the ongoing operation and maintenance of alternative recreation facilities.

Cruise boat navigation between Tri-Cities and Lewiston-Clarkston would no longer be possible if breaching were to occur. Cruise activity could continue on the lower Columbia River, but these cruises would terminate their upriver journey in Tri-Cities. A Northwest River Partners and Pacific Northwest Waterways Association letter stated that American Cruise Lines would cease their Columbia Snake River System operations instead of switching to a shorter cruise to the Tri-Cities (Northwest River Partners and Pacific Northwest Waterways Association, pers. comm., May 6, 2022). The 2020 CRSO EIS did not identify any specific costs associated with tourism and recreation impacts of dam breaching, but it did identify that there would be a loss of income and jobs at the Ports of Clarkston, Whitman, and Lewiston because of the lost cruise ship industry.

While some recreation opportunities reliant on flatwater reservoirs would be lost with dam breaching, new recreation opportunities associated with a free-flowing river could be realized. The 2020 CRSO EIS found that "[A]s the river returns to natural conditions, river-based recreation would increase over time, given that recreational access and infrastructure is developed; the exact long-term beneficial impacts to visitation and social welfare are uncertain, although the losses in reservoir recreation would be offset by increases in river recreation visitors, and may eventually increase to levels and values greater than under the No Action Alternative (pg. M-6-15)."[19] The 2020 CRSO EIS also notes that after adaptation of the industry, "there is the potential for an increase in jobs and income for outfitters, boating companies, and other tourism businesses relative to the No Action Alternative (pg. M-6-12)."[19] It should be noted that if the LSRD were breached, close coordination with tribal nations will be necessary to ensure tribal artifacts and sites currently inundated by the lower Snake River reservoirs will be protected.

Some of the existing activities that currently occur on reservoirs, like certain fishing, boating and wildlife opportunities, could continue with a free-flowing river. Supporters of restoring the lower Snake to a free-flowing river argue that the river is currently underused for recreation, citing national and regional research findings that a river environment is preferred over lake recreation. For example, a contingent behavior study to estimate the value of recreation changes from removing the LSRD predicted there would be an increase in the total number of trips taken to the lower Snake River.[150]

The 2020 CRSO EIS states that in a dam breaching scenario "it is uncertain how the environment might be managed to achieve other resource goals, e.g., fishing regulations and restrictions associated with the ESA-listed species, particularly Chinook salmon, and the effect these management decisions would have on recreation activities (pg. M-6-6)."[19] While there is uncertainty in the timing and process of river restoration, and the time it will take to achieve increases in the number of salmon and other anadromous fish if the LSRD were breached, salmon recovery efforts afforded by dam removal are likely to increase recreational and sportfishing opportunities in the long term. The 2021 Columbia Basin Fund Initial Economic Assessment notes that "sportfishing is already a significant contributor to the regional economy, with the Idaho Department of Labor estimating that fishing brings in $8.6 million[S] per month to Nez Perce and Clearwater Counties.

Closures of steelhead fishing in 2019 negatively impacted surrounding communities, with Idaho Fish and Game estimating that salmon and steelhead anglers spend approximately $350 per trip[S] (pg. 29)."[147]

New opportunities for trails, campgrounds and other recreation-based infrastructure could connect the communities surrounding the LSRD, and recreational, sportfishing and mountain biking opportunities would also have the potential to grow significantly with a free-flowing river. For example, a free-flowing river could enable growth of local rafting, canoeing, kayaking and other boating industries and associated tourism, including the possibility of multi-day rafting trips within the 60-plus rapids that would be accessible if the dams were breached. Before the LSRD were constructed, the Army Corps identified 63 rapids between Lewiston, Idaho and the confluence with the Columbia River.[146] Stakeholders interviewed for this effort noted that demand for recreation and rafting opportunities through free-flowing rivers is steadily increasing, with the odds of securing a permit to float the Snake River through Hells Canyon decreasing from one in six in 2010 to one in 17 in 2020, and for the Salmon River, the odds have decreased from one in 17 in 2010 to one in 43 in 2020.[151]

The potential economic benefits of a new recreational system built around a free-flowing lower Snake River has not been evaluated. However, a 2020 economic analysis of outdoor recreation in Washington State estimates that outdoor recreation in Washington supports $26.5 billion in annual expenditures. The report found that ecosystem services on Washington's public lands, such as clean air and water, habitat for animals, scenic beauty, and recreational enjoyment provide between $216 billion and $264 billion in yearly environmental benefits.[152]

Actions needed to replace or improve services

No formal economic analyses have been completed to date that estimate the total need, cost, and funding sources for potential replacement, modification and expansion of trails, parks, and other recreational facilities if the dams were breached. Similarly, formal cost estimates have not been developed on the need to potentially compensate impacted sport fishers, boaters, and marinas, and invest in recreation and tourism sectors while the impacted areas transition from flat-water to a free-flowing river.

The Simpson Proposal, based on conversations with tribes and stakeholders, provides preliminary estimates for what a tourism and recreation funding package could look like if the LSRD are breached. It contains a $425 million[G] proposed investment package for tourism and recreation including:

- $125 million[G] for development of a national recreation area with river access, campgrounds, boat launches, and other facilities managed by the BLM.
- $125 million[G] in tourism promotion resources for Washington and Idaho to communicate the area's new attractions.
- A $75 million[G] sport fishing contingency fund to offset potential temporary declines in fishing immediately following the breach due to dislodged sediment in the waters.
- $50 million[G] for relocation or compensation of affected marinas.
- $50 million[G] to compensate owners of motorized boats designed for use on lakes.[147]

The Simpson Proposal highlights that significant investment for recreational facilities and compensation for impacted industries may support maintenance of recreational access for Lewis Clark Valley communities determined necessary to maintain and develop new recreational opportunities consistent with a free-flowing river. Over time, these investments could provide significantly improved recreational opportunities compared to the existing system through increased recreational, sportfishing and mountain biking opportunities and growth of the local rafting, canoeing, kayaking and other boating industries and associated tourism.

In addition to investments to support transition in the recreation economy, additional exploration is needed to determine who would manage the newly exposed land after breaching, and for what purposes. A free-flowing river would likely lead to different recreational uses and opportunities along distinct sections of the 140-mile river corridor. Whatever management regime is used for the river corridor post-breaching, e.g., Wild and Scenic River, National Recreation Area, other designation, or a combination of different regimes, and what, if any, new governance structures are needed to support the recreational system need to be defined in advance of dam breaching.

Finally, more analysis is needed to understand how long after breaching it would take for salmon and other aquatic species to increase in abundance, and how salmon recovery could contribute to additional recreational opportunities for sportfishing. Care must also be taken when modifying existing or creating new recreational facilities to ensure protection and safekeeping of tribal artifacts and sites and preserving ADA access.

10. Economic Impacts and Opportunities

The LSRD, since their construction, have created services and economic benefits for some, and economic losses and difficulties for others. The services and benefits the LSRD have provided to communities along the lower Snake River have been described extensively throughout this report and are reiterated below. However, there are losses associated with the dams as well. These losses occur in the form of recreational value associated with adversely impacted fisheries and other river-based activities, and losses to tribes through loss of salmon, access to cultural sites and access to other treaty-reserved rights.

The LSRD do support a wide range of industries and sectors and breaching the dams would have significant impacts on the region if not mitigated. As described throughout this report, the LSRD do provide services and benefits to different industries which then in turn sustain economic activity in the region. Highlights are reiterated below.

> **Navigation and transportation.** Supported by federal funding that subsidizes the cost of operating the LSRD locks, barging enabled by the dams is the lowest-cost option (per ton-mile) for wheat shipping for lower Snake River producers who operate on narrow cost margins and use barging to maximize their profit per bushel. The 2020 CRSO EIS uses 72 cents per bushel of wheat as an average baseline transportation cost for farmers to move their product to a Pacific Northwest port, with rail rates estimated between 50 cents and 75 cents per bushel and barge rates estimated between 30 cents and 45 cents per bushel.[17]
>
> **Irrigation.** Approximately 50,000 acres of farmland is irrigated along the Snake River. AgriNorthwest estimates that the combined production value of irrigated land along the Snake River in 2021 was $327.9 million ($342 million in 2022 dollars[Z]). The 2020 CRSO EIS estimates that the LSRD on the Snake River as they stand support 47,840 acres of irrigated agriculture, $256 million[AA] in labor income, and $14 million to $19 million[BS] in social welfare annually, i.e., the profits above dryland farming that are made possible through irrigation.[18]
>
> **Energy.** The LSRD are one of the least-cost generation resources within BPA's portfolio. This, coupled with the fact that the LSRD allow power managers to efficiently manage the grid, contribute to some of the lowest power rates for customers in the Pacific Northwest, compared to other rate payers in the United States. Additionally, any surplus clean energy that the LSRD provide is highly valued in energy markets and can lead to higher revenues for BPA, which further keep rates down. Current BPA power costs are approximately $31 per MWh, an average made lower by the approximate $14 per MWh LSRD projects at 11% of the BPA portfolio (Snohomish PUD and Tacoma Power, pers. comm., March 4, 2022).[103]
>
> **Recreation.** The series of flatwater reservoirs and locks system as a result of the LSRD provide economic opportunities for recreation along the Snake River and in the Columbia Basin as a whole. The locks system also allows for the cruise industry to operate from Portland, Oregon to Clarkston, Washington. Spending by cruise passengers, crew members, and cruise lines equaled approximately $3.9 million[CL] in the Lewis-Clark Valley area in 2019.[148] The cruise industry

> served 19,000 passengers and provided an estimated 70 total (direct, indirect and induced) jobs to the region that same year, with a total payroll of $1.54 million[CS] during the peak visitor season.[20]

With proper advance planning and investment, the services the LSRD provide can be fully or partially maintained for multiple industries and sectors, and negative impacts of dam breaching can be mitigated. However, some industries will be fundamentally altered if the LSRD were breached. These include tourism, i.e., cruise boats, in and out of the Lewis-Clark Valley, commerce at the Lewiston and Clarkston Ports, and grain transport and storage along the LSRD. To a certain extent, impacts to some of these industries can be mitigated, but it is important to also consider these changes in the context of the broader regional picture. This section focuses on how economies impacted by LSRD breaching could not only replace the economic benefits of the LSRD but expand upon regional opportunities to build an economically diverse and prosperous future.

Considering the broader economic picture for the communities along the lower Snake River can help identify not only ways that the region can replace the services they currently receive from the dams, but also to grow, diversify, and become more resilient in the future. The LSRD enabled Lewiston to be the farthest inland port along the West Coast of the United States. They were built with the promise of prosperity for the region. However, while the Lewis-Clark Valley is particularly important to the regional economy, it has lagged behind the growth of surrounding areas (see Figure 22). The majority of the jobs in the Lewis-Clark Valley are in the government sector, followed by health care and social assistance. With a significant manufacturing base, active economic agencies, and a high quality of life, the region has room to grow and diversify.

Through review of relevant economic reports and conversations with experts, three sectors were identified in the Lewis-Clark Valley to target for future growth: manufacturing, high-technology, and viticulture. Opportunities in these three sectors can be pursued regardless of whether the dams were breached but additional investments as part a program with dam breaching could increase the chance and probability of success. Experts also commonly referenced other needed investments that could support the Lewis-Clark Valley's future. These include improved public transportation infrastructure, pipelines to key industries for young people and recent graduates, pursuit of a community-based approach, and waterfront revitalization in downtown Lewiston and Clarkston. All of these improvements could support job growth in the area and support the Lewis-Clark Valley.

The remainder of this section focuses on the Lewis-Clark Valley, with strong emphasis on the cities of Lewiston and Clarkston, as well as economic activity and opportunities created by and for the Nez Perce Tribe.

Economic overview of the Lewis-Clark Valley

The Lewis-Clark Valley is of particular importance to Washington and Idaho. While Spokane serves as the broader economic hub, Lewiston is a central hub in the region, servicing communities in Clarkston and Pullman, Washington, and Moscow, Kendrick/Juliaetta and Orofino, Idaho.[153] The Lewis-Clark Valley has significant room to grow, with support from economic development agencies such as Valley Vision, Port of Lewiston and Port of Clarkston.

The Lewis-Clark Valley is part of what is known as the Quad County region, inclusive of Asotin, Latah, Nez Perce and Whitman Counties. The Quad County region has four primary economic sectors: manufacturing (much of which is natural resource-based), retail trade, health care and social assistance, and government (including education).[153] As Table 17 illustrates, most jobs are in the government sector, primarily education.

Table 17: Employment by industry for the Quad County region, including Asotin, Latah, Nez Perce, and Whitman Counties in 2021.[153]

Industry	Number of Jobs	Percent of Total Jobs in Region
Government Sector (including education)	21,035	31.0%
Health Care and Social Assistance	8,845	13.0%
Manufacturing	7,185	10.6%
Retail Trade	6,782	10.0%
Accommodation and Food Service	5,539	8.1%
Construction	3,120	5.8%
Other*	15.455	21.5%
Total	**67,961**	**100%**

** Other industries include mining/quarrying, crop and animal production, utilities, wholesale trade, transportation/warehousing, information, finance and insurance, real estate, scientific industries, management of companies, administrative/waste management, arts and entertainment, and other services.*

The fastest growing industry in the Lewis-Clark Valley between 2010 and 2020 was manufacturing, and Nez Perce County leads the region in manufacturing jobs.[153] The largest manufacturing firms in the area are Clearwater Paper, Vista Outdoors, and Schweitzer Engineering, all three of which are included in the top ten regional employers (Table 18). Manufacturing represents a success story for the region. From 2010 to 2020, the Lewis-Clark Valley has increased manufacturing jobs by 78%, while Idaho has increased manufacturing by only 5%. In the same timeframe, Washington saw a 6% decline of manufacturing jobs and the United States saw a decline of 21%.[154] Had the region not experienced this significant growth in the manufacturing sector, Nez Perce County growth would have been negative, likely leading to a recession.[154] Other fast-growing industries in the region include mining, construction, private education, real estate and rental leasing, administration, and construction.

Table 18: Top 10 list of the Lewis-Clark Valley region's largest employers. *Includes seasonal and part time employment.[153]

Rank	Firm/Entity	Employment*
1	Clearwater Paper	1,414
2	Nez Perce Tribe (Lewiston, Lapwai)	1,346
3	Lewiston School District	1,200

Rank	Firm/Entity	Employment*
4	Vista Outdoor	1,177
5	St. Joseph Regional Medical Center	950
6	Lewis Clark State College	750
7	Schweitzer Engineering (Lewiston, ID)	620
8	Costco Wholesale	540
9	Regence BlueShield of Idaho	509
10	Tri-State Memorial Hospital	500

The skilled manufacturing workforce in the Lewis-Clark Valley has recently been accessed by new high-technology industries, including Schweitzer Engineering Laboratories (SEL). SEL is headquartered in Pullman, Washington and recently expanded to Lewiston, ID. This decision was made, in part, because there were already a large number of employees commuting from Lewiston to the Pullman location. Additionally, the Port of Lewiston, where SEL is located, was able to meet the spatial and tenant needs of SEL. The Lewiston SEL site now has over 600 employees and will likely continue to grow as they plan to expand to Moscow, Idaho.[153]

The Quad County region and Lewis-Clark Valley economy has long centered around industries in natural resources, wood products, ammunition manufacturing and mining. However, these industries are defined as either mature or declining and present little opportunity for new employment.[153] Despite some new business entries in the Lewis-Clark Valley, the area has lost between 0.2% to 0.3% of its business establishments annually.[155] Some key industries are highly volatile, including some that have a significant presence in the region.

Impacted industries by LSRD breaching

If the LSRD were breached, there would be negative impacts to some industries. Industries that will not be continued include grain transportation by barge (See Section 5: Navigation and Transportation of Wheat and Other Commodities) and cruise tourism to ports in the Lewis-Clark Valley (See Section 8: Tourism and Recreation). There is uncertainty around the exact impacts on other businesses and industries in the area with some reliance on the LSRD. It is clear that prior to breaching, additional work would be needed to identify broader impacts to the local community and actions that can be taken to maintain and enhance economic vitality in the region.

Through stakeholder interviews, Clearwater Paper was identified as a significant contributor to the local economy, and as Table 18 showed it is the largest single employer in the region, and its operations could be directly impacted by breaching if not mitigated. Clearwater Paper's Lewiston mill is the only site in the company that produces all of the company's products, including paperboard and tissue products. Clearwater has reduced its water usage in recent years. However, the paper production industry remains water intensive, requiring water at multiple stages of production. To maintain production, if water levels are lowered from breaching, the mill would need infrastructure improvements for the intake pipe which draws water from the river and the effluent pipe which puts water back into the river system. As mentioned in the Section 5 on navigation and transportation, the Clearwater mill in Lewiston also relies on barged sawdust and woodchips as operational inputs, which would be impacted by LSRD breaching. The Simpson Proposal estimated contributing $275 million[G] to both adjust infrastructure and mitigate for barged transportation of materials.[32] The majority of this would go towards transportation mitigation, and additional engineering analysis would be needed to develop cost estimates for infrastructure modification.

Economic opportunities for the region

The Lewis-Clark Valley, which is a part of north central Idaho has generally lagged behind the rest of the state and country in economic growth and has lower average regional wages when compared to Idaho, Washington, and US levels (Figure 22).[156]

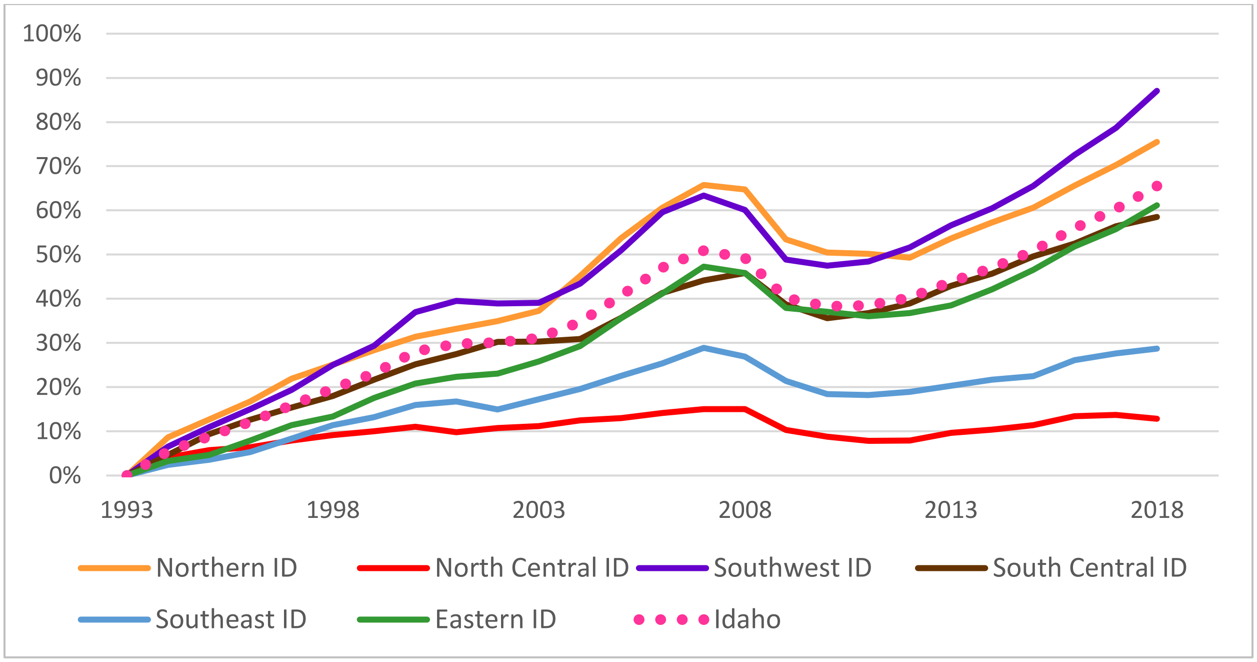

Figure 22: The Lewis-Clark Valley comprises part of the North Central Idaho economic region. Between 1993 and 2018, the North Central Idaho region has seen slower growth compared to the rest of the state. (Source: Idaho Department of Labor/Idaho Conservation League)

In a community needs assessment conducted in 2019, surveys completed by over 2,500 residents of the region and a community forum with residents of Lewiston and Clarkston revealed a need and desire for greater economic opportunity, including higher paying jobs and greater job prospects.[157] Like many areas in the United States, the Lewis-Clark Valley has seen rising costs of living leading to household hardships. The community expressed a desire for a participatory approach, in which stakeholders are driving solutions with different sectors. The maturity, decline, and volatility of key industries, combined with a clear desire from the community, points to a need to identify opportunities to diversify the economy and bring new business to the Lewis-Clark Valley in a way that aligns with community values and needs.

The region has significant opportunity for a more prosperous future, with a large skilled labor force, a steady number of graduates from nearby higher education institutions, and available zoned land for new businesses. These aspects of the region can draw new industries and companies that can contribute to a higher paying, dependable job market.

Manufacturing

A significant aim of economic development agencies in the Lewis-Clark Valley is to ensure maintenance of the manufacturing industry by supporting existing businesses and growing new businesses that fit into the existing supply chains. The Lewis-Clark Valley has historically had a significant amount of skilled labor for the manufacturing industry, which has resulted in companies remaining in the area to expand in addition to attracting new industry. To support manufacturing industry, the region could invest in existing and new manufacturing and entrepreneurial programs, and transportation routes through Lewiston and Clarkston.

Manufacturing incubators and entrepreneurial programs can support new manufacturing jobs in the region. The Port of Lewiston, for example, has a program that provides structured lease rates to qualifying tenants in the manufacturing industry. Tenant businesses should produce products, have already begun production, and show potential for creating new, high-paying jobs. The three-year program enables businesses to grow and transition into permanent facilities. In 2021, the program had already seen two businesses successfully transition out, including Clearwater Canyon Cellars and Seekins Precision.[153] Since 2021, more businesses have transitioned out (Port of Lewiston, pers. comm., April 8, 2022). Ports with business incubators and other similar programs can play a significant role in maintaining and strengthening the manufacturing legacy of the region. If the LSRD were breached, the Ports may need financial support to upkeep these programs and investment could be made to maintain the opportunities created by the Ports and other economic development agencies.

The Lewis-Clark Valley has in part seen growth in manufacturing due to its location along the Snake River, where materials can easily be shipped in via barge and finished products can easily be shipped out. If the dams were breached, barge transportation of materials would no longer be possible. To maintain the manufacturing industry, it may be necessary to invest in highway expansion to support shipping of materials and products from the region.

Economic contributions and opportunities of the Nez Perce Tribe

The Nez Perce Tribe contributes significantly to the regional economy. In 2018, tribal gross revenues and expenditures from primary operations and other activities was approximately $150 million with a total economic impact on regional output (total sales) of nearly $196 million.[156] The tribe is also a top employer in the region, directly providing over 1,200 jobs in 2021.[153] The Nez Perce Tribe is strategically increasing self-reliance by pursuing investments that expand the local economy. So far, the tribe has invested in a new business park and training center and has invested in a viticulture operation and winery. The Nez Perce Tribe Economic Impact Report (2021) also provides information on potential future investment by the tribe to increase self-reliance, including sustainable agriculture and viticulture, vegetable and berry processing, bioenergy, expansion of hotel accommodations and complements to gaming facilities, and bioenergy, among others.

High-technology

High-technology industry has already begun to grow in the Lewis-Clark Valley with the movement of SEL to the Lewiston area. The Nez Perce Tribe and others have expressed an interest in growing high-tech industry in the region, as it has the potential to bring more, high-paying and dependable jobs. In order to attract and grow high-tech industry to the Lewis-Clark Valley, investments could be made in continued fiber optic expansion, addition of business travel amenities, and siting and development of research and data centers.

Modern industries often require dependable broadband connections, and several entities have already expanded coverage across the region to support existing and potential new businesses. For example, the Port of Lewiston has partnered with Clearwater Economic Development Agency (CEDA) and others to invest $5.6 million in expansion of dark fiber optic infrastructure in the region.[153] The Port of Whitman County installed 140 miles of fiber as of 2020, with a specific emphasis on rural communities.[78] Installing fiber in rural communities can draw new businesses and reinvigorate local economies. The Nez Perce Tribe has also expanded fiber optic across the Reservation and surrounding area, as a means to provide services to residents and make the area more attractive to broader industry.[156] Investments could be made to continue this fiber optic expansion in partnership with Ports, economic development agencies, and the Nez Perce Tribe.

Access to airports for regular business travel is essential for companies and industries to consider moving to an area. The Lewis-Clark Valley has the Lewiston Nez Perce County Airport, which is jointly owned by the City of Lewiston and Nez Perce County and administered by a local airport authority. The airport has two runways with daily direct flights to Denver, CO and Salt Lake City, UT, with the hopes of expanding east and west to other major airports. Though tourism contributes significantly to total annual passengers, business related travel provides consistent income for the airport and connections between the Lewis-Clark Valley and other areas of the United States can make the region more attractive for businesses. Another important consideration is access to other amenities that are desirable for business travel. The airport has recently undergone expanding their parking facilities and developing a hotel and restaurant in Lewiston, which can further facilitate business travel (Lewiston-Nez Perce County Airport, pers. comm. March 30, 2022). Investments can be made to expand business travel accommodations, including business housing, rental cars, among other key items.

The Nez Perce Tribe has been exploring the possibility of attracting a data center to the region (Nez Perce Tribe, pers. comm., March 31, 2022). Data centers require water to cool the systems, which makes the Lewis-Clark Valley ideal with its position along the Snake River. Breaching would not be expected to impact water availability for this type of venture. The Simpson Proposal included the idea of developing an energy research center. The proposed program would be led by Pacific Northwest National Laboratory and would build a research park and technology campus in the Lewis-Clark Valley. The Simpson Proposal included $250 million to site, develop, and construct the research park and technology campus, as well as a series of grants that would be provided for universities and tech innovation.[32] Similar investments could be made to promote and draw in high-tech industry for the region, either for energy research or to support data center development by the Nez Perce Tribe.

Viticulture development

In 2016, 306,560 acres of the Lewis-Clark Valley was certified as an American Viticulture Area (AVA) in portions of Nez Perce, Lewis, Clearwater and Latah Counties in Idaho and Asotin, Garfield, and Whitman Counties in Washington.[158] The Lewis-Clark Valley AVA is distinct from the Snake River Valley AVA, which spans Idaho and Oregon. The designation by the Alcohol and Tobacco Tax and Trade Bureau allows vintners to better describe the origin of their wines to consumers.[158] According to the Lewis Clark Valley Wine Alliance, there are 16 vineyards and nine wineries in the Lewis-Clark Valley AVA that produce 20 unique varietals. During multiple conversations with agencies and stakeholders, viticulture was mentioned as an industry with significant room to grow. If the region were interested in supporting the growth of viticulture, investments could be made in prioritizing areas for growing wine grapes, supporting existing wine alliances and priorities of the alliances, and marketing the region as a unique AVA and as a tourist destination.

Despite the Lewis-Clark Valley AVA containing over 300,000 acres, not all this land is necessarily ideal for grape growing. In order for the industry to grow, there needs to be land made available for small and medium-sized producers.[159] The region has already begun the process of plotting land to determine which would be suitable for grape growing, with the support of a Rural EDA grant (Visit LC Valley, pers. comm. April 12, 2022). However, greater investments can be made to scope land and develop supporting infrastructure for wine growers, such as banks that specialize in wine finance.

The designation of the Lewis-Clark Valley as a distinct AVA is a significant step in supporting growth of the wine industry in the region by improving marketability of wines from the region, and in turn brand awareness. Across Idaho, wine tourism is most popular in the Boise area and to date has been less popular in Lewiston due to its distance from other major cities. Development of a wine tourism industry can support economic growth, primarily due to spending by tourists on goods and services as part of the tourism experience, including spending on hotel stays, restaurants, and other local travel expenses. Existing tourism reports show that visitors engaging in wine tourism spent an estimated $108.9 million on various non-wine goods and services in Idaho in 2017, with an average of $409[CO] spent per visitor.[159] Wine tourism is just beginning in the Lewis-Clark Valley, and as the industry grows and more producers join the market, investments could be made to improve marketing of the vineyards and create greater tourism opportunities.

Clusters of wine industries typically have supporting organizations, financing infrastructure, and training support that can help grow businesses. This wine-specific infrastructure is beginning to develop, with the local wineries having formed the Lewis Clark Valley Wine Alliance and could grow as more producers join. Monetary support for the Alliance or similar groups that may develop in the future would support the wine industry.

Stimulating economic development in the Lewis-Clark Valley

A number of economic development agencies are present in the region, working to promote industry and job growth. In addition to traditional economic development agencies, such as Valley Vision, the Ports in the region play a vital role in economic development, contributing to industry by providing access to entrepreneurial programs and critical infrastructure. The Nez Perce Tribe has also played a critical role in economic growth of the region, contributing significant investments in new business, infrastructure and industries. A group of partners in the region, including CEDA, Valley Vision, Beautiful Downtown Lewiston, and the City of Lewiston, supported a feasibility study for an innovation hub in Lewiston that would provide co-working space, conference space and facilities for small businesses.[155] The Lewiston Innovation Hub would hope to reinvigorate downtown Lewiston, and kick-start small business formation and retention in the Lewis-Clark Valley. This type of innovative thinking and support provided by these entities is essential to both maintaining and growing industry presence in the Lewis-Clark Valley.

Through discussions with stakeholders, industry representatives, and economic development agencies, a range of actions and investments were identified to support economic growth in the Lewis-Clark Valley. It should be noted that the Lewis-Clark Valley is ripe with opportunities to diversify and expand its economy, and this report provides a sample of what is possible.

> **Transportation infrastructure.** Nez Perce County is a regional jobs supplier, and nearly 25% of workers commute from outside of Nez Perce and Asotin Counties.[153] During calls with stakeholders, it was mentioned that there used to be public transportation between Lapwai and Moscow in Latah County. However, because it was funded through a grant, the route stopped running once the grant ran out. In a community needs assessment for the region conducted in 2019, 19% of Nez Perce County and 22% of southeast Washington participants identified public transportation as a community aspect most in need of improvement.[157] It may be worth exploring how the region could provide public transportation to service surrounding cities and rural areas to draw in workers and support those currently commuting.
>
> **Pipelines to industries.** Multiple individuals referenced the need for pipelines to funnel people in to key industries. Employers in the area typically received a large number of applicants for open positions, but due to changing demographics in the area, it may be beneficial to support entrance into certain industries by new graduates and younger workers. The Idaho Wine Economic Impact Report suggested providing courses in wine making and viticulture at nearby universities to support entrance into the wine industry.[159] Similarly, the airport has experienced a shortage of airline pilots in the past and is working to provide flight training as part of university curriculum at Lewis-Clark College (Nez Perce-Lewiston County Airport, pers. comm., March 30, 2022). Offering educational pathways can be a way to strategically funnel new graduates into key industries in the Lewis-Clark Valley. CEDA has recently started the Inland Northwest Workforce Council to solve workforce issues in the region. For example, the group has introduced a Hospital Cohort which includes eight hospitals from Grangeville, Idaho to Pomeroy, Washington with the purpose of building pipelines for high priority staffing needs in the health care industry (Valley Vision, pers. comm., April 14, 2022). This type of program can be valuable in introducing young people to career options in the region for other high-paying industries, such as utilities and manufacturing, and keeping them in the area.

Waterfront revitalization. The LSRD have long been a part of the community identity of the Lewis-Clark Valley and have created recreational opportunities since their construction (See: Recreation Section 8). In the event the dams were breached, the waterfront would change. There have been some plans that outline a new waterfront with a system of shopping and restaurants, as well as a more extensive network of walking and biking paths. The Simpson Proposal includes $150 million[G] for Lewiston-Clarkston waterfront restoration.[32] Given the immense changes the waterfront will incur and how these changes will impact quality of life, it would be essential to scope this reimagining of the waterfront in a way that aligns with community values and the priorities of Lewiston and Clarkston.

Communities and businesses in the Lewis-Clark Valley are closely identified with the Snake River and the LSRD system. If the dams were breached, this identity would shift and one option is for the region to offer support through direct investment to stimulate the economy and expand upon what the Valley already has to offer. For example, the Simpson Proposal included $150 million[G] for Lewiston-Clarkston Waterfront Restoration and $100 million Economic Development Fund for the Lewiston-Clarkston Area.[32] A BERK report on the Simpson Proposal stated that these investments could be phased with 20% being deployed prior to breaching, 25% of the funds being deployed during the transition, and 55% deployed during the adoption phase.[147] Waterfront revitalization could be key in promoting the region as a tourist location, in concert with new outdoor recreation opportunities, e.g., fishing and rafting, as described in the Recreation Section. The Simpson Proposal also included a $75 million[G] Economic Development Fund for the Tri-Cities Area.[32] Though this section of the report does not focus on the Tri-Cities, there certainly will be economic impacts to the broader region that will need to be assessed and addressed.

Investments to support the Lewis-Clark Valley transition would be valuable to the region. The renewed emphasis on repairing and improving infrastructure across the country represents an opportunity to position the region for a sustainable economic future. There are multiple opportunities to broaden and strengthen the economic base of the Lewis-Clark Valley to create more resilience and diversity to spur more growth. If done correctly and with proper planning, this broadening and strengthening of the economy can be done in concert with restoring salmon and tribal treaty rights and culture in a dam breaching scenario.

11. Summary of Overall Replacement and Mitigation Costs

Based on previous studies, replacing the services provided by the dams could range in cost from $10.3 billion to $31.3 billion (see Table 19), and anticipated costs are still not available for several necessary actions, including long-term operations and maintenance. There was a wide range in the level of detail and assumptions for the analyses used to develop cost estimates. For example, the cost for energy replacement varies greatly depending on a number of issues including the source of energy, technological advances, location of new sources and many other factors. If breaching were to move forward, all cost estimates would need to be refined through additional technical work and collaboration with affected parties.

All dollar values are expressed in April or May 2022 values unless otherwise noted. The dollar values from the original reports were adjusted to 2022 dollars using a variety of price indices, including the Bureau of Economic Analysis's GDP Price Deflator, the Engineering News-Record Construction Cost Index, the Bureau of Reclamation's Operation and Maintenance Cost Index, and sector-specific producer price indices. To highlight costs in total present value terms (the value in today's dollars of the stream of expected costs over the next 50 years), the analysis uses a 50-year time horizon and the federal water resources planning rate of 2.25%.

Table 19: Summary of LSRD estimated replacement and mitigation costs across categories

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
Energy	Energy Replacement	CRSO EIS	$9.3 billion - $18.6 billion	The low-cost estimate is for the Least Cost portfolio and the high-cost estimate is for the Zero Carbon Portfolio. Includes capital and operating costs, transmission upgrades, and demand response
Energy		Energy Strategies (2022)	$8.3 billion to $9.3 billion	The low-cost estimate is for the BPA Net Position portfolio and the high-cost estimate is for the BPA Load Shape portfolio. Includes capital and operating costs of renewable energy portfolios Does not include transmission upgrades, grid connection costs, or other system upgrades (anticipated by the authors to be small)
Energy		E3 (2022)	$13.0 billion to $22.7 billion	The low-cost estimate is for the Scenario 1a portfolio and the high-cost estimate is for the Scenario 2a portfolio

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
				Costs represent those required for firm capacity power replacement Includes transmission costs The low-end value assumes emerging technologies become commercially viable. The report also includes a high-cost estimate of $49 billion to $89 billion. These high-end values assume no combustion resources and no technological breakthroughs for emerging technologies, and high increased electricity loads due to increased electrification.
Energy		Energy GPS (2022)	$41.5 billion to $56.9 billion	Costs represent the cost of constructing 14.9 GW of name plate resources due to assumed low effective capacity rates that only 9% to 12% of the new resources can be utilized to meet demand. Does not include costs for transmission, increased electrification, or land use/permitting of new infrastructure, or emergence of new technologies. The Energy GPS report estimates $15 billion costs from 2030 to 2045 with annual recurring costs of $2.5 billion from 2046 to 2080 for replacing the energy of the lower Snake River Dams. The present value cost range of $41.5 billion to $56.9 billion reported is reflective of the way dollar values are presented throughout this report, i.e., a 50-year time horizon and the federal water resources planning rate of 2.25%
Energy		Simpson Proposal	$16 billion	Includes "Clean Firm Power Replacement", lower Columbia "Salmon Spill" replacement power, NW Grid Resiliency and Optimization
Breaching	Breaching the Dams	CRSO EIS	$1.24 billion	Includes the costs of breaching, revegetation, and cultural resources protection
Breaching		EcoNW	$1.37 billion	Includes dam removal, revegetation, mobilization and contingencies, and environmental mitigation
Breaching		Simpson Proposal	$2 billion	Includes the costs of breaching, sedimentation, revegetation, and cultural resources protection
Navigation & Transportation	Navigation & Transportation Mitigation	EcoNW	$542 million to $588 million	Includes costs to shipper, emission, accidents, road wear and tear, road infrastructure, and rail infrastructure

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
Navigation& Transportation		CRSO EIS	$969 million to $1.3 billion	Includes costs for road repairs and maintenance, a shuttle rail facility, rail infrastructure, rail and road armoring and dredging
Navigation& Transportation		FCS Group	$3.7 billion to $4.8 billion	Includes cost of replacing transportation benefits of dams, emissions, accidents, roadway maintenance, and direct farm payments
Navigation& Transportation		Simpson Proposal	$4.5 billion	Includes cost of infrastructure upgrades to ports, rail, and roads; payments to shippers
Irrigation	Irrigation Infrastructure Mitigation	2002 Army Corps EIS	$1.0 billion ($787 million capital cost, $218 million in present value of annual maintenance cost)	Deepen 71 wells, create a common pump station for Ice Harbor irrigators, and maintain annually surface water withdrawal.
Irrigation		EcoNW	$188 million	Deepen wells and modify related infrastructure and mitigate for 41 surface water withdrawals along the Snake River.
Irrigation		Simpson Proposal	$750 million	Complete any structural changes required for affected irrigation intakes, outflows, wells or other structures related to irrigation along the lower Snake River
Recreation	Recreation infrastructure Mitigation	Simpson Proposal	$425 million	National Recreation Area development, tourism promotion, sportfishing fund, relocation of marinas, compensation of motorized boat owners
Economic Development	Investment in Lewis-Clark Valley	Simpson Proposal	$325 million	Lewiston-Clarkston waterfront restoration, general economic development funds

Section	Mitigation Type	Source	Present Value Cost (2022)	Notes
Total	**Total costs all mitigation measures**	**Low estimates in each category added together. High estimates in each category added together.**	**$10.3 billion to $31.3 billion**	**Low end estimate does not include Simpson Proposal for recreation and community development.** **High end estimate does not include the high-cost estimate from the E3 report or the Energy GPS findings for energy replacement due to the substantial amount of replacement resources these studies call for compared to other comparative studies. The Energy GPS study determined that 15GW of replacement resources were necessary to maintain reliability and the high-cost scenario for the E3 study determined that 13GW was necessary, both values of are 4 to 5 times larger than the replacement capacities determined in the CRSO EIS, i.e., 3.5GW. Additionally, Senator Murray and Governor Inslee have determined an energy replacement portfolio only relying on intermittent resources is not a valid path forward.**

Given the potential magnitude of these costs, significant federal investment will be needed. Funding from the recently enacted Infrastructure Investment and Jobs Act, for example, could be applied to defray the costs of road, rail, and water infrastructure, and provide economic development through improvement of broadband services.

References

[1] *United States v. Winans*, 198 U.S. 371, 381 (1905).

[2] *United States v. Washington,* 506 F.Supp. 187, 203 (W.D. Wash. 1980).

[3] *Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n,* 443 U.S. 658, 679 (1979.

[4] *Northwest Sea Farms v. U.S. Army Corps of Engineers,* 931 F. Supp. 1515, 1520 (W.D. Wash. 1996).

[5] CRITFC. (2022). *2022 Energy Vision for the Columbia River Basin*. Prepared by the Columbia River Inter-Tribal Fish Commission.

[6] NOAA. (2022). Draft Rebuilding Interior Columbia Basin Salmon and Steelhead Report. Retrieved from: https://www.fisheries.noaa.gov/resource/document/draft-rebuilding-interior-columbia-basin-salmon-and-steelhead-report

[7] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix E. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[8] Affiliated Tribes of Northwest Indians, Resolution #2021-23 (May 2021), https://atnitribes.org/wp-content/uploads/2021/06/Res-2021-23.pdf

[9] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Executive Summary. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[10] Meyer Resources, Inc. (1999). Tribal Circumstances and Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes. Columbia River Inter-Tribal Fish Commission. Retrieved from: https://www.critfc.org/wp-content/uploads/2014/11/circum.pdf?x78172

[11] NOAA Fisheries. (2020). A Vision for Salmon and Steelhead: Goals to Restore Thriving Salmon and Steelhead to the Columbia River Basin. Retrieved from: https://www.fisheries.noaa.gov/vision-salmon-and-steelhead-goals-restore-thriving-salmon-and-steelhead-columbia-river-basin

[12] Hanson, M.B., C.K. Emmons, M.J. Ford, M. Everett, K. Parsons, L.K Park, J. Hempelmann, D.M. Van Doomik, G.S. Schorr, J.K. Jacobsen, M. F. Sears, M.S. Sears, J.G. Sneva, R.W. Baird, and L. Barre. (2021) Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. PLoS ONE 16(3): e0247031. Retrieved from: https://doi.org/10.1371/journal.pone.0247031

[13] Couture F., G. Oldford, V. Christensen, L. Barrett-Lennard, C. Walters. (2022) Requirements and availability of prey for northeastern pacific southern resident killer whales. PLoS ONE 17(6): e0270523. Retrieved from: https://doi.org/10.1371/journal.pone.0270523

[14] NMFS. (2008). Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*), p. II-82. National Marine Fisheries Service, Northwest Region, Seattle, WA. Retrieved from: http://www.nwr.noaa.gov/Marine-Mammals/Whales-Dolphins-Porpoise/Killer-Whales/ESA-Status/Orca-Recovery-Plan.cfm

[15] Mandell-Rice, J.R. and S.E. Amberson. (August 30, 2021). EPA Reissues Temperature TMDLs in the Columbia and Lower Snake Rivers. Van Nezz Feldman. Retrieved from: https://www.vnf.com/epa-reissues-temperature-in-the-columbia-and-lower-snake-rivers

[16] BPA, River Management Joint Operating

Committee (RMJOC)II, August 2020,
https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/9936
[17] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix L. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[18] USACE. (2002). Final Lower Snake River Juvenile Salmon Migration Feasibility Study, Appendix I. Retrieved from: https://www.nww.usace.army.mil/Portals/28/docs/library/2002%20LSR%20study/Appendix_I.pdf?ver=2019-05-03-141214-350

[19] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix F. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[20] McDowell Group. (2020). Lewis Clark Valley Cruise Industry: Economic Impact Assessment. Prepared for Port of Lewiston and Port of Clarkston. Retrieved from: https://portofclarkston.com/wp-content/uploads/2021/04/Riverboat-Econ-Impacts-Report-10_20_20-rev.pdf

[21] USACE (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix Q. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[22] BPA. (2020). *Strategic Asset Management Plan*. Prepared for: CRSO. Retrieved from: https://www.bpa.gov/-/media/Aep/finance/asset-management/management-plans/20201009-fcrps-samp.pdf

[23] BPA. (2020). BP-22 Integrated Program Review, June 2020. Retrieved from: https://www.bpa.gov/-/media/Aep/finance/integrated-program-review/bp-22-ipr/20200612-BP-22-IPR-Initial-Detailed-Publication.pdf

[24] BPA. (2022). Graphs and tables used in the FY 2021 Columbia River Basin F&W Program Costs Report (Document 2022-1). Retrieved from: https://www.nwcouncil.org/f/17398/2022-1.xlsx

[25] BPA. (2022). 2022 Hatcheries Strategic Asset Management Plan. Retrieved from: https://www.bpa.gov/-/media/Aep/finance/asset-management/management-plans/2022-efw-hatchery-samp.pdf

[26] US EPA. (2018). Assessment of Climate Change Impacts on Temperatures of the Columbia and Snake Rivers. US EPA Region 10. Retrieved from: https://www.epa.gov/sites/default/files/2019-10/documents/columbia-river-cwr-plan-appendix-16.pdf

[27] BPA, River Management Joint Operating
Committee (RMJOC)II, August 2020,
https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/9936
[28] USACE (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix Q. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[29] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Chapter 2. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[30] Drawdown Regional Economic Workgroup (DREW), US Army Corps of Engineers. (1999). *Water Supply Analysis*. Retrieved from: http://www.nww.usace.army.mil/Library/2002-LSR-Study/DREW/

[31] ECONorthwest. (2019). Lower Snake River Dams Economic Tradeoffs of Removal. Prepared for Vulcan Inc. Retrieved from: https://static1.squarespace.com/static/597fb96acd39c34098e8d423/t/5d41bbf522405f0001c67068/1564589261882/LSRD_Economic_Tradeoffs_Report.pdf

[32] Congressman Mike Simpson. (2021). The Northwest in Transition: Salmon, Dams and Energy – What If? Retrieved from: https://simpson.house.gov/uploadedfiles/websiteslides2.4.pdf

[33] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix C. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[34] Kramer, B. (2014, April 15). Drawdown of Columbia River reservoir creates problems, opportunities. *The Spokesman Review*. Retrieved from: https://www.spokesman.com/stories/2014/apr/15/drawdown-of-columbia-river-river-reservoir-cr/

[35] Storch, A.J., H.A. Schaller, C.E. Petrosky, R.L. Vadas Jr., B.J. Clemens, G. Sprague, N. Mercado-Silva, B. Roper, M.J. Parsley, E. Bowles, R.M., Hughes, J.A. Hesse. (2022). A review of potential conservation and fisheries benefits of breaching four dams in the Lower Snake River (Washington, USA). *Water Biology and Security (in press).*

[36] Welch, D.W., A.D. Porter, E.L. Rechisky. (2021). A synthesis of the coast-wide decline in survival of West Coast Chinook Salmon (*Oncorhynchus tshawytscha,* Salmonidae). *Fish and Fisheries*, 22: 194– 211. Retrieved from: https://doi.org/10.1111/faf.12514

[37] NOAA Fisheries and US Department of Commerce. (2021). *Snake River Coho Restoration*. Retrieved from: https://www.webapps.nwfsc.noaa.gov/apex/f?p=309%3A19%3A%3A%3A%3AP19_PROJECTID%3A43237076

[38] Pollock, W. (2021, September 2). We can have our salmon and eat it, too. *The Register-Guard*. Retrieved from: https://www.registerguard.com/story/opinion/columns/2021/09/02/guest-view-we-can-have-our-salmon-and-eat-it-too-hydro-power-killer-whales-chinook-oregon-idaho/5657156001/

[39] Fish Passage Center. (2022, July 11). Memorandum: Comparison of 2022 spring Chinook at Lower Granite Dam with historical years. Retrieved from: https://www.fpc.org/documents/memos/43-22.pdf

[40] Crozier, L.G., B.J. Burke, B.E. Chasco, D.L. Widener, R.W. Zabel. (2021). Climate change threatens Chinook salmon throughout their life cycle. *Communications Biology,* 4: 222. Retrieved from: https://doi.org/10.1038/s42003-021-01734-w

[41] Siegel, J.E., and L.G. Crozier. (2020). Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019. *NOAA Institutional Repository*. Retrieved from: https://doi.org/10.25923/jke5-c307

[42] Save Our Wild Salmon. (2021, February 22). Scientists' letter on the need for lower Snake River dam removal to protect salmon and steelhead from extinction and restore abundant, fishable populations. Retrieved from: https://www.wildsalmon.org/images/2021.Sci.Letter.Final.2.22.21.pdf

[43] Welch, D. (2021, March 17). 68 Scientists' letter on the need for lower Snake River dam removal is wrong. Retrieved from: http://kintama.com/wp-content/uploads/2021/03/Welch-Letter-to-the-Governors-Legislators-17-March-2021.pdf

[44] Independent Scientific Advisory Board for the NWPCC, Columbia River Basin Tribes, and NMFS. (2021). Review of the Coast-Wide Analysis of Chinook Salmon Smolt to Adult Returns (SARs) by Welch et al. Retrieved from: https://www.nwcouncil.org/media/filer_public/75/7d/757df48e-5095-413c-b51d-81460338e3b6/ISAB_2021-3_ReviewOfWelchEtAl2020CoastWideSARs_29June.pdf

[45] Columbia Basin Partnership Task Force. (2020). Phase 2 Report of the Columbia Basin Partnership Task Force of the Marine Fisheries Advisory Committee: Executive Summary. Retrieved from:

https://www.fisheries.noaa.gov/vision-salmon-and-steelhead-goals-restore-thriving-salmon-and-steelhead-columbia-river-basin

[46] Northwest Power and Conservation Council. (2020). *2020 Addendum to the 2014 Columbia River Basin Fish and Wildlife Program*. Retrieved from: https://www.nwcouncil.org/reports/2020-9/

[47] Petrosky, C.E., H.A. Schaller, E.S. Tinus, T. Copeland, and A.J. Storch. (2020), Achieving Productivity to Recover and Restore Columbia River Stream-Type Chinook Salmon Relies on Increasing Smolt-To-Adult Survival. *North American Journal of Fisheries Management,* 40: 789-803. Retrieved from: https://doi.org/10.1002/nafm.10449

[48] Trout Unlimited. (2022). The worst Snake River salmon and steelhead returns in over 200 years. Retrieved from: https://www.tu.org/lowersnake/

[49] CRITFC. (2014). Wy-Kan-Ush-Mi Wa-Kish-Wit, Spirit of the Salmon (1995), Updated in 2014. Retrieved from: https://critfc.org/fish-and-watersheds/fish-and-habitat-restoration/the-plan-wy-kanush- mi-wa-kish-wit-2/

[50] DeHart, M. (2022). *Comparative Survival Study of PIT-Tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye 2021 Annual Report*. Bonneville Power Association. Retrieved from: https://www.fpc.org/documents/CSS/2021_CSS_Annual_Report.pdf

[51] M.W. Shields, J. Lindell, and J. Woodruff. (2018) Declining spring usage of core habitat by endangered fish-eating killer whales reflects decreased availability of their primary prey. *Pacific Conservation Biology,* 24: 189-193. Retrieved from: https://doi.org/10.1071/PC17041

[52] Mesa, M., and C. Magie, (2006). Evaluation of energy expenditure in adult spring Chinook salmon migrating upstream in the Columbia River Basin: An assessment based on sequential proximate analysis. *River Research and Applications*, 22:1085–1095. Retrieved from: http://doi.org/10.1002/rra.995

[53] O'Neill, S.M., G.M. Ylitalo, J.E. West. (2014). Energy content of Pacific salmon as prey of northern and Southern Resident Killer Whales. *Endangered Species Research,* 25: 265–281. Retrieved from: https://www.int-res.com/articles/esr_oa/n025p265.pdf

[54] Groskreutz, M.J., J.W. Durban, H. Fearnbach, L.G. Barrett-Lennard, J.R. Towers, J.K.B. Ford. (2019). Decadal changes in adult size of salmon-eating killer whales in the eastern North Pacific. *Endangered Species Research,* 40: 183-188. Retrieved from: https://doi.org/10.3354/esr00993

[55] NMFS. (2021). Revision of the Critical Habitat Designation for Southern Resident killer whales: Final Biological Report (to accompany the Final Rule). Retrieved from: https://repository.library.noaa.gov/view/noaa/31587

[56] Ayres K.L., R.K. Booth, J.A. Hempelmann, K.L. Koski, C.K. Emmons, R.W. Baird, K. Balcomb-Bartok, M.B. Hanson, M.J. Ford, S.K. Wasser. (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (*Orcinus orca*) Population. *PLoS One,* 7: e36842. Retrieved from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0036842

[57] Wasser, S.K., J.I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons, and R. Booth. (2017). Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). *PLoS One,* 12(6): e0179824. Retrieved from: https://doi.org/10.1371/journal.pone.0179824

[58] *Muckleshoot Indian Tribe v. United Sates Corps of Engineers,* 698 F.Supp. 1504, 1510 (W.D. Wash. 1988), *citing Menominee Tribe of Indians v. United States,* 391 U.S 404, 411-412, 88 S.Ct. 1705, 1710-1711 (1968).

[59] *Cherokee Nation v. Georgia*, 30 U.S. 1 (1831); *Worcester v. Georgia*, 31 U.S. 515 (1832); *Northwest Sea Farms, v. U.S. Army Corps of Engineers*, 931 F. Supp. 1515, 1520 (W.D. Wash. 1996).

[60] Mapes, L. (2020, November 29). Salmon People: A tribe's decades long fight to take down the lower snake river dams and restore a way of life. *The Seattle Times*. Retrieved from: https://www.seattletimes.com/seattle-news/environment/salmon-people-a-tribes-decades-long-fight-to-take-down-the-lower-snake-river-dams-and-restore-a-way-of-life/

[61] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix P. Retrieved from: https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/14965

[62] National Congress of American Indians, Resolution #AK-21-009 (June 2021), https://ncai.org/AK-21-009.pdf

[63] The United States, White House. (2022, March 28). *Columbia River Basin Fisheries: Working Together to Develop a Path Forward.* Retrieved from: https://www.whitehouse.gov/ceq/news-updates/2022/03/28/columbia-river-basin-fisheries-working-together-to-develop-a-path-forward/

[64] NOAA Fisheries. (2022). Fisheries Economics of the United States Report, 2019. Retrieved from: https://www.fisheries.noaa.gov/resource/document/fisheries-economics-united-states-report-2019

[65] Idaho Outfitters and Guides, Association Columbia Basin Initiative | Rep Simpson Plan, 2020, Retrieved from: https://drive.google.com/file/d/1d5nQQgZZsyXQQyD0GYKOg5CjywsL8BQ9/view

[66] Washington State Department of Agriculture. (2022). *Export Statistics*. Retrieved from: https://agr.wa.gov/departments/business-and-marketing-support/international/statistics

[67] Waterborne Commerce of the United States (WCUS) Ports and Waterways Web Tool (http://cwbi-ndc-nav.s3-website-us-east-1.amazonaws.com/files/wcsc/webpub/#/)

[68] Stern, C.V. and N.T. Carter. (2018). Congressional Research Service: In Focus. Inland Waterways Trust Fund, Updated February 26, 2018. Retrieved from: https://crsreports.congress.gov/product/details?prodcode=IF10020

[69] Macrotrends. (2022). Wheat Prices – 40 Year Historical Chart. Retrieved from: https://www.macrotrends.net/2534/wheat-prices-historical-chart-data

[70] Gastelle, J. and P. Caffarelli. (2020). Rail Rates for Grain Shipments over Time (Summary). U.S. Department of Agriculture, Agricultural Marketing Service. Retrieved from: http://dx.doi.org/10.9752/TS255.03-2020

[71] FCS. (2020). National Transportation Impacts & Regional Economic Impacts Caused by Breaching Lower Snake River Dams. Prepared for: Pacific Northwest Waterways Association.

[72] Jessup, E.L. and K.L. Casavant. (1998). *Impact of Snake River Drawdown on Transportation of Trains in Eastern Washington: Competitive and Rail Car Constraints.* Retrieved from: http://ses.wsu.edu/wp-content/uploads/2015/03/err24.pdf

[73] Jaller, M. (2022). Grain Transportation Study Final Report. Prepared for American Rivers and The Water Foundation. Retrieved from: https://www.americanrivers.org/conservation-resource/study-snake-river-grain-transportation-and-carbon-emissions/

[74] Zaturanov, S. (2022, May 30). A Forecast of The Trucking Crisis as We Head Into 2022. *Forbes*. Retrieved from: https://www.forbes.com/sites/forbestechcouncil/2022/03/30/a-forecast-of-the-trucking-crisis-as-we-head-into-2022/?sh=3b0b12144475

[75] U.S. Government Interagency Working Group on Social Cost of Greenhouse Gases. (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide – Interim Estimates under Executive Order 13990. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[76] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Chapter 7. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[77] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Chapter 3. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[78] Peterson, S. (2020). Economic Contributions of the Port of Whitman County. Prepared for Port of Whitman County. Retrieved from: https://www.portwhitman.com/economic-impacts

[79] Sage, J., K. Casavant, J.B. Eustice. (2015). *Washington State Short Line Rail Inventory and Needs Assessment*. Freight Policy Transportation Institute, Washington State University. Retrieved from: ses.wsu.edu/wp-content/uploads/2015/07/FPTI-19.pdf

[80] Washington Department of Transportation. (2020). *Washington State Rail Plan, 2019 – 2040*. Retrieved from: https://wsdot.wa.gov/sites/default/files/2021-10/2019-2040-State-Rail-Plan.pdf

[81] Mathia, J. (2018, January 24). New Rail spur at Endicott will aid unit train shipments". *Whitman County Gazette*. Retrieved from: https://www.wcgazette.com/story/2018/01/03/news/new-rail-spur-at-endicott-will-aid-unit-train-shipments/24428.html

[82] David Evans and Associates Inc. (2014). *Northport Transportation Study*. Prepared for: Lewis-Clark Valley MPO. Retrieved from: https://www.lewisclarkmpo.org/DocumentCenter/View/250/Northport-Study-Final-Report

[83] Washington Department of Ecology. (2018). Washington State Greenhouse Gas Inventory. Retrieved from: https://ecology.wa.gov/Air-Climate/Climate-change/Tracking-greenhouse-gases/GHG-inventories

[84] Washington Department of Commerce. (2020). Washington 2021 State Energy Strategy: Transitioning to an Equitable Clean Energy Future. December 2020. https://www.commerce.wa.gov/wp-content/uploads/2020/12/Washington-2021-State-Energy-Strategy-December-2020.pdf

[85] Washington Department of Commerce. (2020). Washington 2021 State Energy Strategy: Transitioning to an Equitable Clean Energy Future. December 2020. Appendix B: Data Accompanying Deep Modeling Technical Report, Tab S3 (Washington Generation and Load) and Tab D2 (Final Energy Demand). https://www.commerce.wa.gov/wp-content/uploads/2020/12/Appendix-B.-Data-Accompanying-WA-SES-EER-DDP-Modeling-Report-12-11-2020.xlsx

[86] Energy+Environmental Economics. (2022). BPA Lower Snake River Dams Power Replacement Study. Retrieved from: https://www.ethree.com/wp-content/uploads/2022/07/e3-bpa-lower-snake-river-dams-power-replacement-study.pdf

[87] Casavant, K. and T. Ball (2001). Impacts of a Snake River Drawdown on Energy and Emissions, Based on Regional Energy Coefficients. Final Technical Report. https://rosap.ntl.bts.gov/view/dot/37728

[88] Washington Department of Ecology. (2021). Clean Fuel Standard. Retrieved from: https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Clean-Fuel-Standard

[89] Washington Department of Ecology. (2021). Chapter 173-423 WAC and WAC 173-400-025. Retrieved from: https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC-173-423-400

[90] Hill, J.S. (2022, 6 May). Electric trucks are coming: Volvo opens orders for heavy duty, Volta targets US Market. *The Driven*. Retrieved from: https://thedriven.io/2022/05/06/electric-trucks-are-coming-volvo-opens-orders-for-heavy-duty-volta-targets-us-market/

[91] BNSF. (2019, 7 August). BNSF Leads the Charge on Testing Batter-Electric Locomotive. Retrieved from: https://www.bnsf.com/news-media/railtalk/service/battery-electric-locomotive.html

[92] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix G. Retrieved from: https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/14965

[93] Bureau of Reclamation. (2019). *Columbia River Diversions and Irrigated Agricultural Acres*. US Department of the Interior. Retrieved from: https://usace.contentdm.oclc.org/digital/api/collection/p266001coll1/id/9931/download

[94] USDA. (2021). Land Values 2021 Summary. August 2021. Retrieved from: https://www.nass.usda.gov/Publications/Todays_Reports/reports/land0821.pdf

[95] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix N. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[96] American Rivers. (2021). Irrigation along the Lower Snake River after dam breaching. Prepared by: Blue Spruce Strategies.

[97] NWPCC. (2021). "Defining the Region". Retrieved from: https://www.nwcouncil.org/2021powerplan_defining-region/

[98] HydroReview Content Director. "BPA Report: Lower Snake River Dams Helped Region Power through Recent Heatwave." Hydro Review, 28 July 2021, https://www.hydroreview.com/environmental/bpa-report-lower-snake-river-dams-helped-region-power-through-recent-heatwave/

[99] Northwest Power and Conservation Council. (2021). 2021 Northwest Power Plan. Retrieved from: https://www.nwcouncil.org/sites/default/files/2021powerplan_2021-5.pdf

[100] NERC. (2022). *US Reliability Standards*. Retrieved from: https://www.nerc.com/pa/Stand/Pages/USRelStand.aspx

[101] WECC. (2022). *Standards*. Retrieved from: https://www.wecc.org/Standards/Pages/default.aspx

[102] Washington State Legislature, *RCW 19.405.020 Definitions*, 7/6/22. Retrieved from: https://app.leg.wa.gov/RCW/default.aspx?cite=19.405.020

[103] Connolly, C. (2022). *Smart Planning Will Drive Replacing the Power from Lower Snake River Dams*. Prepared for Northwest Energy Coalition. Retrieved from: https://nwenergy.org/wp-content/uploads/2022/02/Planning-for-Energy-Replacement-Feb-2022-1.pdf

[104] Connolly, C. (April 7, 2022). Addressing the Lower Snake River Dams' Peaking Capacity. Prepared for Northwest Energy Coalition. Retrieved from: https://nwenergy.org/featured/addressing-the-lower-snake-river-dams-peaking-capacity/

[105] de Chalendar, J.A., J. Taggart, S.M. Benson. (2019). Tracking Emissions in the US Electricity System. *Proceedings of the National Academy of Sciences*, 116 (51) 25497-25502. https://doi.org/10.1073/pnas.1912950116

[106] BPA. (n.d.). *Transmission Services*. Retrieved from: https://www.bpa.gov/energy-and-services/transmission#

[107] Northwest Power and Conservation Council. (n.d.). Transmission. Retrieved from: https://www.nwcouncil.org/2021powerplan_transmission/

[108] USACE. (2020). Final Environmental Impact Statement: Columbia River System Operations, Appendix H. Retrieved from: https://www.nwd.usace.army.mil/CRSO/Final-EIS/

[109] Washington State Department of Commerce. (2022, March 28). Overview: Clean Energy Transformation Act (CETA). Retrieved from: https://www.commerce.wa.gov/growing-the-economy/energy/ceta-overview/

[110] Cline, S. (2021, July 27). Oregon Governor Signs Ambitious Clean Energy Bill. *Oregon Public Broadcasting*. Retrieved from: https://www.opb.org/article/2021/07/27/oregon-governor-signs-ambitious-clean-energy-bill/

[111] Haley, B. (2020, March 16). Northwest Deep Decarbonization. *Evolved Energy Research*. Retrieved from: https://www.evolved.energy/post/2019/06/11/northwest-deep-decarbonization-pathways-1

[112] PNUCC. (2022). Northwest Regional Forecast of Power Loads and Resources: 2022 through 2032. Retrieved from: https://www.pnucc.org/wp-content/uploads/2022-PNUCC-Northwest-Regional-Forecast-final.pdf

[113] Idaho Power. (2021). Idaho Power Integrated Resource Plan. Retrieved from: https://docs.idahopower.com/pdfs/AboutUs/PlanningforFuture/irp/2021/2021%20IRP_WEB.pdf

[114] Engrossed Substitute Senate Bill 5974, State of Washington 67th Legislature. (2022). https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Senate%20Passed%20Legislature/5974-S.PL.pdf?q=20220512193815

[115] Washington State Department of Commerce. (2021). Washington State Energy Strategy. Retrieved from: https://www.commerce.wa.gov/wp-content/uploads/2020/12/Washington-2021-State-Energy-Strategy-December-2020.pdf

[116] USACE, BPA and Bureau of Reclamation. (2020). Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition (RMJOC-II). Part II: Columbia River Reservoir Regulation and Operations – Modeling and Analyses. Retrieved from: https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/9936

[117] Northwest Power and Conservation Council. (2021). *Method to Estimate Climate Change Wind Generation*. Retrieved from: https://www.nwcouncil.org/2021powerplan_method-to-estimate-climate-change-wind-generation/

[118] National Renewable Energy Laboratory. (2021). 2021 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. Retrieved from: https://atb.nrel.gov/

[119] US Solar Institute. (2018). *Capacity Factor*. Retrieved from: https://www.myussi.com/glossary/capacity-factor/

[120] Ong, S., C. Clinton, P. Denholm, R. Margolis, G. Heath. (2013). *Land-Use Requirements for Solar Power Plants in the United States*. National Renewables Energy Lab, United States Department of Energy. Retrieved from: https://www.nrel.gov/docs/fy13osti/56290.pdf

[121] Energy GPS. (2022). Lower Snake River Dams Power Supply Replacement Analysis. Prepared for Northwest RiverPartners. Retrieved from: https://nwriverpartners.org/wp-content/uploads/2022/06/EGPSC_LSRD-Power-Cost-Replacement-Study_6_29_2022_Final_1223.pdf

[122] Murray, C. (2022, April 25). CPUC approves California utility projects including PG&E's 1.6GW/6.4Wh BESS. *Energy Storage News*. Retrieved from: https://www.energy-storage.news/cpuc-approves-california-utility-projects-including-pges-1-6gw-6-4gwh-bess/

[123] Ruth, M.F., P. Jadun, N. Gilroy, E. Connelly, R. Boardman, A.J. Simon, A. Elgowainy, J. Zuboy. (2020). The Technical and Economic Potential of the H2@Scale Concept within the United States. National Renewable Energy Laboratory (NREL/TP-6A20-77610). Retrieved from: https://www.nrel.gov/docs/fy21osti/77610.pdf

[124] U.S. Department of Energy. (n.d.). *Hydrogen Basics*. Retrieved from: https://afdc.energy.gov/fuels/hydrogen_basics.html

[125] BPA. (n.d.). Glossary: electrolysis. Retrieved from: https://afdc.energy.gov/glossary.html#Electrolysis

[126] Banse, T. (2021, March 8). Hydrogen production plan groundbreaking signals renewed interest in alt fuel. *NW News Network*. Retrieved from: https://www.nwnewsnetwork.org/energy/2021-03-08/hydrogen-production-plant-groundbreaking-signals-renewed-interest-in-alt-fuel

[127] MacDonald, N. (2021, November 4). Seattle City Light Explores Renewable Hydrogen Fuel at the Port of Seattle with Department of Energy Awards. *Seattle City Light*. Retrieved from: https://powerlines.seattle.gov/2021/11/04/seattle-city-light-explores-renewable-hydrogen-fuel-at-the-port-of-seattle-with-department-of-energy-awards/

[128] Economic Alliance of Lewis County. (2022, March 31). State Passes Hydrogen Clean Energy Support Legislation: Lewis County Poised to Be a Regional 'Hydrogen Hub'. *The Chronicle*. Retrieved from: https://www.chronline.com/stories/state-passes-hydrogen-clean-energy-support-legislation-lewis-county-poised-to-be-a-regional,287080

[129] U.S. Department of Energy. *Hydrogen Laws and Incentives in Washington*. Retrieved from: https://afdc.energy.gov/fuels/laws/HY?state=WA

[130] Northwest Power and Conservation Council. (2021). *Demand Response and the Northwest Power Act*. Retrieved from: https://www.nwcouncil.org/2021powerplan_demand-response-and-northwest-power-act/

[131] Northwest Power and Conservation Council. (2021). *Conservation in the Power Act*. Retrieved from: https://www.nwcouncil.org/2021powerplan_conservationinpoweract/

[132] U.S. Department of Energy, Wind Energy Technologies Office. (2022). *Offshore Wind Research and Development*. Retrieved from: https://www.energy.gov/eere/wind/offshore-wind-research-and-development

[133] NOAA Fisheries. (2022). *Offshore Wind Energy*. Retrieved from: https://www.fisheries.noaa.gov/topic/offshore-wind-energy

[134] Calkins, R. (2021, December 15). Washington's Moment to Shine in Offshore Wind Energy. *Port of Seattle*. Retrieved from: https://www.portseattle.org/commission-blog/2604/washingtons-moment-shine-offshore-wind-energy

[135] Turner, Nicholas. (2022, April 11). Seattle developer pushes for WA's first floating offshore wind farm off Olympic Peninsula. *The Seattle Times*. Retrieved from: https://www.seattletimes.com/seattle-news/environment/seattle-developer-pushes-for-was-first-floating-offshore-wind-farm-off-olympic-peninsula/

[136] U.S. Department of State. (2021). *Columbia River Treaty*. Retrieved from: https://www.state.gov/columbia-river-treaty/

[137] BPA and US Department of Energy. (2021). 2022 Power Rate Schedules and General Rate Schedule Provisions (FY 2022-2023). Retrieved from: https://www.bpa.gov/-/media/Aep/rates-tariff/bp-22/bp-22-final-decision/2022-Power-Rate-Schedules-and-GRSPs_Rev_12-15-21.pdf

[138] Bonneville Power Administration. (2022). *How BPA spends a dollar of its power revenue: BP-22 rate period (Oct. 1, 2021, through Sept. 30, 2023).* Retrieved from: https://www.bpa.gov/-/media/Aep/rates-tariff/rates/bp22-dollar-infographic-final.pdf

[139] Washington State Department of Commerce. (2019). *Cowlitz County Energy Needs Assessment*. Retrieved from: https://www.commerce.wa.gov/growing-the-economy/energy/ceta-energy-assistance/

[140] "RCW 19.405.120 Energy Assistance for Low-Income Households." Washington State Legislature, https://app.leg.wa.gov/RCW/default.aspx?cite=19.405.120

[141] Energy Strategies. (2018). Lower Snake River Dams Power Replacement Study. Prepared for Northwest Energy Coalition. Retrieved from: https://nwenergy.org/featured/lsrdstudy/

[142] Energy Strategies. (2022). Lower Snake River Dam Replacement Study. Prepared for Northwest Energy Coalition. Retrieved from: https://nwenergy.org/issues/fish-wildlife/lower-snake-river-dam-replacement-study-energy-strategies/

[143] Energy+Environmental Economics. (2017). Pacific Northwest Low Carbon Scenario Analysis: Achieving Least-Cost Carbon Emissions Reductions in the Electricity Sector. Retrieved from: https://www.ethree.com/wp-content/uploads/2018/01/E3_PGP_GHGReductionStudy_2017-12-15_FINAL.pdf

[144] Energy+Environmental Economics. (2019). Capacity Needs of the Pacific Northwest – 2019 to 2030. Retrieved from: https://www.ethree.com/wp-content/uploads/2019/12/E3-PNW-Capacity-Need-FINAL-Dec-2019.pdf

[145] Energy+Environmental Economics. (2019, December 2). E3 Projects Substantial Capacity Shortfall in the Pacific Northwest. Retrieved from: https://www.ethree.com/e3-projects-substantial-capacity-shortfall-in-the-pacific-northwest/

[146] Final Lower Snake River Juvenile Salmon Migration Feasibility Study, Part II, Ch. 5. https://www.nww.usace.army.mil/Portals/28/docs/library/2002%20LSR%20study/Section05.pdf?ver=2019-05-03-132034-137

[147] BERK Consulting. (2021). *Columbia Basin Fund: Initial Economic Assessment*. Retrieved from: https://static1.squarespace.com/static/5a08d32918b27d4c1ef79eb7/t/608881017d52fb441f5cdda5/1619558658985/Columbia+Basin+Fund+-+Initial+Economic+Assessment+2021+0421.pdf

[148] McDowell Group. (2021). *Lewis Clark Valley Cruise Boat Industry Needs Assessment*. Prepared for the Port of Lewiston and Port of Clarkston. Retrieved from: https://portofclarkston.com/wp-content/uploads/2021/04/Riverboat-Needs-Assessment-FINAL-3_18_21.pdf

[149] Fly LWS. (2022, March 30). Lewiston Airport Offers Passengers More Places to Travel this Summer. Retrieved from: https://www.golws.com/press-release-lewiston-airport-offers-passengers-more-places-to-travel-this-summer/?utm_source=rss&utm_medium=rss&utm_campaign=press-release-lewiston-airport-offers-passengers-more-places-to-travel-this-summer

[150] Loomis, J. (2002). Quantifying recreation use values from removing dams and restoring free-flowing rivers: A contingent behavior travel cost demand model for the Lower Snake River. *Water Resources Research*, 38 (6).

[151] USDA Forest Service. (2021). Four Rivers Lottery Statistics. Retrieved from: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5408633.pdf

[152] Mojica, J., Fletcher, A., 2020. Economic Analysis of Outdoor Recreation in Washington State, 2020 Update. Earth Economics. Tacoma, WA.

[153] Peterson & Associates. (2021). *The 2021 Port of Lewiston Economic Influence on the Regional Economy*. Prepared for Port of Lewiston. Retrieved from: https://portoflewiston.com/wp-content/uploads/2021/11/POL_2021_Final_v1-1.pdf

[154] Peterson, S. (2018). *The Economic Impacts of the Nez Perce Tribe on the Regional Economy*. Prepared for the Nez Perce Tribe.

[155] Valley Vision. (2021). *Lewiston Innovation Hub Feasibility Study*. Retrieved from: https://lewis-clarkvalley.org/wp-content/uploads/2021/05/Innovation-Hub-Feasability-Study.pdf

[156] Peterson, S. (2018). *The Economic Impacts of the Nez Perce Tribe on the Regional Economy*. Prepared for the Nez Perce Tribe.

[157] Burley, M. (2019). A Region-wide Community Needs and Opportunity Assessment: Community Data Indicators and Strategic Philanthropic Plan for the Lewis-Clark Valley Healthcare Foundation. Innovia Foundation. Retrieved from: https://www.idahopublichealth.com/district2/dataresources/FinalNAReport-DEC2019.pdf

[158] Establishment of the Lewis-Clark Valley Viticultural Area and Realignment of the Columbia Valley Viticultural Area, 81 FR 23156 (2016). https://www.federalregister.gov/documents/2016/04/20/2016-09264/establishment-of-the-lewis-clark-valley-viticultural-area-and-realignment-of-the-columbia-valley

[159] Idaho Wine Commission. (2019). *Idaho Wine Commission Economic Impact Study*. Retrieved from: https://idahowines.org/wp-content/uploads/CAI.ID-Wine-Commission.Econ-Impacts.Final-Report.-2019-0916.pdf

Appendix A: List of Individuals Contacted for Report

Information for this report was gathered through a combination of literature and document review, telephone and online interviews and discussions, and an online feedback form. During the literature review, the project team assembled and reviewed publicly available information from recent studies and task forces described above to understand perspectives on the services and benefits provided by the LSRD, document potential means to replace those services and benefits were the dams to be breached and compile associated cost estimates. The consultant team also engaged with Washington state agencies to gather feedback or make use of their respective topical area expertise.

Interviews were carried out with tribal sovereigns, stakeholders, advisors and experts from across the region who have experience and expertise with the issues surrounding the benefits, effects, and concerns with retaining or breaching the LSRD, as well as opportunities to provide similar or better services if the dams were to be breached. Most of the interviews were conducted with a two-member team. Some calls were conducted with one individual, whereas others were group interviews. To encourage interviewees to be as candid as possible, this report does not attribute specific statements to individual interviewees unless interviewees approved their attribution. In some cases, the consulting team had email or phone communications and provided briefings on the report to groups or individuals.

Organization	Name
AgriNorthwest	Blaine Meek
AgriNorthwest	Dennis Wright
AgriNorthwest	Jens Rasmussen
American Cruise Lines	Kristin Meira
American Queen Steamboat Company	Andrea Michelson
American Whitewater	Tom O'Keefe
Ben Franklin Transit	Ed Frost
Benton PUD	Lori Saunders
Benton PUD	Rick Dunn
BNSF Railway	Johan Hellman
Bonneville Power Administration	Eve James
Bonneville Power Administration	Liz Klumpp
Bonneville Power Administration	Robert Diffley
Bureau of Reclamation	Eric Rothwell
Bureau of Reclamation	Roland Springer

Organization	Name
Burns Paiute Tribe	Calla Hagle
Burns Paiute Tribe	Diane Teeman
California Independent System Operator	Elliott Mainzer
Center for Biological Diversity	Brett Hartl
Chelan Public Utility District	Kirk Hudson
CHS Primeland	Ken Blakeman
City of Asotin	Dwayne Paris
City of Benton	Linda Lehman
City of Clarkston	Monika Lawrence
City of Clarkston	Adam McDaniel
City of Connell	Lee Barrow
City of Kennewick	Gretl Crawford
City of Pasco	Joseph Campos
City of Pasco	Nikki Torres
City of Prosser	Randy Taylor
City of West Richland	Kate Moran
Clearwater Paper	Matt Van Vleet
Coeur d'Alene Tribe	Angelo Vitale
Coeur d'Alene Tribe	Hemmy James
Coeur d'Alene Tribe	Ralph Allan
Colorado State University	Dr. John Loomis
Columbia River Inter-Tribal Fish Commission	Aja DeCoteau
Columbia River Inter-Tribal Fish Commission	Charles Seaton
Columbia River Inter-Tribal Fish Commission	Christine Golightly
Columbia River Inter-Tribal Fish Commission	Dianne Barton
Columbia River Inter-Tribal Fish Commission	Doug Hatch
Columbia River Inter-Tribal Fish Commission	Jeremy FiveCrows
Columbia River Inter-Tribal Fish Commission	Jim Heffernan
Columbia River Inter-Tribal Fish Commission	Laura Gephart

Organization	Name
Columbia River Inter-Tribal Fish Commission	Mike Matylewich
Columbia River Inter-Tribal Fish Commission	Paul Ward
Columbia River Inter-Tribal Fish Commission	Rob Lothrop
Columbia River Inter-Tribal Fish Commission	Tom Lorz
Columbia Snake River Irrigators Association	Darryll Olsen
Columbia Snake River Irrigators Association	Patrick Boss
Confederated Salish and Kootenai Tribes of the Flathead Nation	Chelsea Cole
Confederated Salish and Kootenai Tribes of the Flathead Nation	John Harrison
Confederated Salish and Kootenai Tribes of the Flathead Nation	Ryan Rusche
Confederated Salish and Kootenai Tribes of the Flathead Nation	Stu Levit
Confederated Tribes and Bands of the Yakama Nation	Bill Bosch
Confederated Tribes and Bands of the Yakama Nation	Dave Blodgett
Confederated Tribes and Bands of the Yakama Nation	Daylen Isaac
Confederated Tribes and Bands of the Yakama Nation	Delano Saluskin
Confederated Tribes and Bands of the Yakama Nation	Donella Miller
Confederated Tribes and Bands of the Yakama Nation	Elaine Harvey
Confederated Tribes and Bands of the Yakama Nation	Ethan Jones
Confederated Tribes and Bands of the Yakama Nation	Gerald Lewis
Confederated Tribes and Bands of the Yakama Nation	Jeremy Takala
Confederated Tribes and Bands of the Yakama Nation	Jessica Houston
Confederated Tribes and Bands of the Yakama Nation	Joe Blodgett
Confederated Tribes and Bands of the Yakama Nation	Kate Marckworth
Confederated Tribes and Bands of the Yakama Nation	Phil Rigdon
Confederated Tribes and Bands of the Yakama Nation	Terry Heemsah
Confederated Tribes and Bands of the Yakama Nation	Virgil Lewis
Confederated Tribes of the Colville Reservation	Bret Nine
Confederated Tribes of the Colville Reservation	Charissa Eichman
Confederated Tribes of the Colville Reservation	Cody Desautel
Confederated Tribes of the Colville Reservation	Jarred Erickson

Organization	Name
Confederated Tribes of the Colville Reservation	Jeannette Finley
Confederated Tribes of the Colville Reservation	Kirk Truscott
Confederated Tribes of the Umatilla Indian Reservation	Brent Hall
Confederated Tribes of the Umatilla Indian Reservation	Don Sampson
Confederated Tribes of the Umatilla Indian Reservation	Eric Quaempts
Confederated Tribes of the Umatilla Indian Reservation	Gordon Kenny
Confederated Tribes of the Umatilla Indian Reservation	Kat Brigham
Confederated Tribes of the Umatilla Indian Reservation	Ken Hall
Confederated Tribes of the Umatilla Indian Reservation	Matt Johnson
Confederated Tribes of the Umatilla Indian Reservation	Paul Rabb
Confederated Tribes of the Warm Springs	John Ogan
Consultant for PNWA	Justin LeBlanc
Cowlitz Indian Tribe	Rudy Salakory
Cowlitz Public Utility District	Gary Huhta
Cowlitz Public Utility District	Steve Taylor
DamSense	Jim Waddell
Douglas County Public Utility District	Andrew Gingerich
Douglas County Public Utility District	Gary Ivory
Douglas County Public Utility District	Shane Bickford
Douglas County Public Utility District	Shiloh Burgess
Earth Justice	Todd True
East Columbia Basin Irrigation District	Craig Simpson
Flathead Electric Cooperative	Mark Johnson
Fort McDermitt Shoshone and Paiute Tribe	Scott Hauser
Foss Maritime Company	Sam Diedrick
Franklin County	Brad Peck
Friends Committee on National Legislation	Cindy Darcy
Greater Hells Canyon Council	Andrea Malmberg
Greater Hells Canyon Council	Christina de Villier

Organization	Name
Greater Hells Canyon Council	Darilyn Parry Brown
Highline Grain	Paul Katovich
House of Representatives, 9th District	Representative Joe Schmick
Idaho Conservation League	Justin Hayes
Idaho Conservation League	Jim Norton
Idaho Conservation League	Mitch Cutter
Idaho Falls Power	Bear Prairie
Idaho Grain Producers Association	Stacey Katseanes Satterlee
Idaho Outfitters and Guides Association	Aaron Liebermann
Idaho Outfitters and Guides Association	Jon Kittell
Idaho Outfitters and Guides Association	Roy Akins
Idaho River Adventures	Dustin Ahern
Idaho Wheat Commission	Casey Chumrau
Idaho Wheat Growers	Amanda Hoey
Indivisible Chapters (OR, WA & ID)	Beverly Sherrill
Indivisible Chapters (OR, WA & ID)	Craig Lacy
Indivisible Chapters (OR, WA & ID)	Don Miller
Indivisible Chapters (OR, WA & ID)	Jerry Freilich
Indivisible Chapters (OR, WA & ID)	Patti Kramer
Indivisible Chapters (OR, WA & ID)	Paulette Wittwer
Indivisible Chapters (OR, WA & ID)	Rod Couch
Inland Power and Light	Jasen Bronec
Kalispel Tribe of Indians	Deane Osterman
Kalispel Tribe of Indians	Joe Maroney
Lewiston Clarkston Terminal Inc.	Jerry Kiekow
Lewiston-Nez Perce County Airport	Mike Isaacs
McGregor Corporation	Alex McGregor
McGregor Corporation	Craig Chatterton
McGregor Corporation	Leslie Druffel

Organization	Name
Nez Perce Tribe	Ann McCormack
Nez Perce Tribe	Samuel Penney
Nez Perce Tribe	Darren Williams
Nez Perce Tribe	Dave Cummings
Nez Perce Tribe	Dave Johnson
Nez Perce Tribe	Kayeloni Scott
Nez Perce Tribe	Shannon Wheeler
Northwest Grain Growers	Chris Peha
Northwest RiverPartners	Kurt Miller
Northwest Sportfishing Industry Association	Liz Hamilton
NW Energy Coalition	Fred Heutte
NW Energy Coalition	Lauren McCloy
NW Energy Coalition	Nancy Hirsh
Oregon Department of Agriculture	James Johnson
Oregon Department of Agriculture	Jess Paulson
Oregon Department of Transportation	Erik Having
Oregon Dept of Energy	Adam Schultz
Oregon Dept of Energy	Alan Zelenka
Oregon Dept of Energy	Janine Benner
Oregon Dept of Fish and Wildlife	Ed Bowles
Oregon Dept of Fish and Wildlife	Tucker Jones
Oregon Governor's Office	Jim McKenna
Pacific Northwest Farmers Cooperative	Shawn O'Connell
Pacific Northwest Waterways Association	Dena Horton
Pacific Northwest Waterways Association	Heather Stebbings
Palouse Regional Transportation Planning Organization	Shaun Darveshi
PNGC Power	Roger Gray
Pomeroy Grain	Derek Teal
Port of Benton	Diahann Howard

Organization	Name
Port of Benton	Roy Keck
Port of Clarkston	Wanda Keefer
Port of Columbia County	Sean Clark
Port of Kennewick	Tim Arntzen
Port of Lewiston	Dave Doeringsfeld
Port of Lewiston	Mike Thomason
Port of Pasco	Randy Hayden
Port of Pasco	Vicki Gordon
Port of Whitman County	Joe Poire
Port of Whitman County	Kara Riebold
Port of Whitman County	Kristine Meyer
Port of Whitman County	Sarah Highfield
Port of Whitman County	Tom Kammerzell
Prosser Economic Development Association	Neal Ripplinger
Public Power Council	Michael Deen
Public Power Council	Scott Simms
Pyramid Communication	John Hoyt
Recreational Boaters Association of Washington	Bill Grey
Recreational Boaters Association of Washington	Cal Coie
Recreational Boaters Association of Washington	Doug Larsen
Recreational Boaters Association of Washington	Doug Levy
Recreational Boaters Association of Washington	Loyd Walker
Recreational Boaters Association of Washington	Wayne Gillam
Save Our Salmon	Sam Mace
Seattle City Light	Debra Smith
Seattle City Light	Emeka Anyanwu
Seattle City Light	Josh Walter
Seattle City Light	Maura Brueger
Seattle City Light	Mike Haynes

Organization	Name
Shaver Transportation	Rob Rich
Shaver Transportation	Steve Shaver
Shoshone-Bannock Tribes	Daniel Stone
Shoshone-Bannock Tribes	Lytle Denny
Shoshone-Paiute Tribes	Chris Cleveland
Sierra Club	Bill Arthur
Snohomish Public Utilities District	Garrison Marr
Snohomish Public Utilities District	John Harlow
Snohomish Public Utilities District	Kim Johnston
Southeast Washington County Commissioners (Asotin County)	Brian Shinn
Southeast Washington County Commissioners (Columbia County)	Marty Hall
Southeast Washington County Commissioners (Garfield County)	Justin Dixon
Southeast Washington County Commissioners (Snake River Salmon Recovery Board)	John Foltz
Southeast Washington County Commissioners (Walla Walla)	Todd Kimball
Southeast Washington County Commissioners (Whitman County)	Michael Largent
Spokane Tribe of Indians	Brent Nichols
Spokane Tribe of Indians	Chad McCrea
Spokane Tribe of Indians	Ted Knight
Sunheaven Farms	Howard Jensen
Suquamish Tribe	Leonard Forsman
Tacoma Public Utilities	Chris Robinson
Tacoma Public Utilities	Logan Bahr
Tacoma Public Utilities	Ray Johnson
Temco Terminals	Michelle Adams
The Office of Representative Mike Simpson	Lindsey Slater
Tidewater	Brian Fletcher
Tidewater	Bruce Reed
Tidewater	Craig Nelson
Tidewater	Jennifer Riddle

Organization	Name
Tri-Cities Economic Development Council	David Reeploeg
Tri-Cities Economic Development Council	Karl Dye
Trout Unlimited	Rob Masonis
United Grain	Augusto Bassanini
University of Idaho	Steve Peterson
Upper Columbia United Tribes	DR Michel
Upper Columbia United Tribes	Kevin Malone
Upper Columbia United Tribes	Laura Robinson
Upper Columbia United Tribes	Marc Gauthier
Upper Snake River Tribes	Dennis Daw
Upper Snake River Tribes	Zoe Roberts
US Army Corps of Engineers	Beth Coffey
US Army Corps of Engineers	Rebecca Weiss
Valley Vision	Scott Corbitt
Visit LC Valley	Michelle Peters
Visit Tri-Cities	Kim Shugart
Washington Black Lives Matter Representative	Sakara Remmu
Washington Grain Commission	Glen Squires
Washington Grain Commission	Mary Palmer Sullivan
Washington Potato Commission	Matt Harris
Washington Public Ports Association	James Thompson
Washington Public Utility District Association	Nicolas Garcia
Washington State Parks	Scott Griffith
Washington Wheat Growers Association	Michelle Hennings
Washington Wheat Growers Association	Trey Forsyth
WaterWatch Oregon	John DeVoe
WSDOT South Central District	Todd Trepanier
WSU Freight Policy Transportation Institute	Eric L. Jessup

Appendix B: Questions Provided in the Online Feedback Form

The questionnaire was part of a process to gather information to identify the services currently provided by the four lower Snake River dams (LSRD) and the opportunities to provide similar or better services if the dams were to be breached. Breaching is defined as removal of the earthen embankments, abutments, and portions of existing structures at the dams to eliminate the reservoirs behind the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. The results will be considered as the consultant team develops its report to Governor Inslee and Senator Murray. The results of the questionnaire are not intended for use in any statistical analysis.

Background information

1. Please select the option(s) that best represent your affiliation. You may select more than one option.
   - ☐ Conservation
   - ☐ Sport of Commercial Fishing
   - ☐ Agriculture
   - ☐ For-profit Company
   - ☐ Tribe
   - ☐ Local Government
   - ☐ Business
   - ☐ Recreation
   - ☐ Not-for-profit Organization
   - ☐ Federal Government
   - ☐ State Government
   - ☐ Interested Citizen
   - ☐ Other (please specify)

2. What is your zip code?

The questions are listed in the following categories where current benefits would have to be replaced if the dams are breached: Irrigated agriculture, Navigation and Transportation, Energy, Tourism and Recreation, Community Wellbeing, and Economic Prosperity. You may answer as many categories as you want, and you can skip questions by pressing "Next" at the end of each section. At the end of the survey is a category for "other" where you can provide any additional information you would like to share.

3. What is your primary interest regarding the lower Snake River dams?

Irrigated agriculture

4. For agriculture irrigated with water from the lower Snake River reservoirs or groundwater associated with the reservoirs, what benefits need to be addressed if the dams are breached?
5. What actions could provide similar or greater benefits?

Navigation and transportation

6. For navigation and transportation associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
7. What actions could provide similar or greater benefits if the dams are breached?

Energy

8. For energy associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
9. What actions could provide similar or greater benefits if the dams are breached?

Tourism and recreation

10. For tourism and recreation associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
11. What actions could provide similar or greater benefits if the dams are breached?

Community wellbeing

12. For supporting community well-being (environmental, social, and economic resources) associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
13. What actions could provide similar or greater benefits if the dams are breached?

Economic prosperity

14. For economic prosperity associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
15. What actions could provide similar or greater benefits if the dams are breached?

Other

16. For any other issue associated with the four lower Snake River dams, what benefits need to be addressed if the dams are breached?
17. What actions could provide similar or greater benefits if the dams are breached

Appendix C: Economic Methodology for Conversion of Cost Estimates

All dollar values throughout the report are expressed in April or May 2022 values unless otherwise noted. The dollar values from the original reports were adjusted to 2022 dollars using a variety of price indices, including the Bureau of Economic Analysis's GDP Price Deflator, the Engineering News-Record Construction Cost Index, the Bureau of Reclamation's Operation and Maintenance Cost Index, and sector-specific producer price indices. For every dollar value updated to 2022 dollars, information on the index and methodology used is provided here. To highlight costs in total present value terms (the value in today's dollars of the stream of expected costs over the next 50 years), the analysis uses a 50-year time horizon and the federal water resources planning rate of 2.25%.

A/ The original values were presented as annual totals in nominal or contemporary dollars, which summed to $16.846 billion. The values in each year were adjusted separately for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator and then summed together.

B/ The original value of $52,134,000 in 2018 dollars was adjusted for inflation to 2020 dollars using the Bureau of Reclamation Operations & Maintenance Cost Index and further adjusted to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

C/ The original values of $45 to $60 million in 2020 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

D/ The original values of $300 to $400 million in 2020 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

E/ The original total value of $1.078 billion (the sum of $953 million, $53 million, $52 million, and $20 million) in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

F/ The original value of $1.161 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

G/ Because this value is a recently proposed Congressional allocation, it is was not adjusted from its original value.

H/ The original values of $40,690,000 and $77,672,000 in 2018 dollars were converted to an annual value using the terms in the original study: a 20-year period and a 2.75% discount rate. The annual values were then adjusted back to a present value using the same period and the discount used in this study: 2.25%. This adjusted present value was then adjusted to 2022 dollars using the average of 1) the Bureau of Labor Statistics' Producer Price Index for General Freight Trucking, and 2) the Bureau of Labor Statistics' Producer Price Index for Rail Transportation of Freight and Mail.

I/ The FCS report estimated the annual cost of emissions to be $7.1 million using per-unit values of emissions from Table A-6 of the 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs published by the Office of the Secretary U.S. Department of Transportation. We adjusted the estimate using the per-unit emission values from the 2022 version of the same report. The 2022 report did not include an updated value for volatile organic compounds (VOCs), so we omitted those from our estimate; however, the effect on the updated estimate is likely minimal since VOCs comprised less than 0.01% of the total value of emissions in the FCS estimate.

J/ The original value of $20,375,000 in 2018 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator. To derive the annual value, the original study report time frame of 20 years and discount rate of 2.75% was used.

K/ These estimates were already in 2022 dollars and were therefore not adjusted for inflation.

L/ The original value of $675 million in 2019 dollars (which is the sum of two different costs presented in the CRSO EIS of $203 million and $472 million) was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

M/ The original values of $669 million to $1.1 billion in 2019 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

N/ The original values of $14 to $17 million (representing the present value using a 2.75% discount rate over 20 years) in 2018 dollars were adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads. As it is not clear to what extent this infrastructure would need to be replaced over the 50 year time, we did not extrapolate from these values to a 50-year time horizon.

O/ The original values of $113 million to $135 million in 2018 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index. As it is not clear to what extent this infrastructure would need to be replaced over the 50 year time, we did not extrapolate from these values to a 50-year time horizon.

P/ The original value of $358 million (the sum of two estimates in the original report: $291.5 million and $67.04 million) in 1998 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

Q/ The original value of $3,500,000 in 1998 dollars was adjusted for inflation to 2020 dollars using the Bureau of Reclamation Operations & Maintenance Cost Index and further adjusted to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator. The value was converted to a present value over 50 years using a 2.25% discount rate.

R/ The original value of $160 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

S/ No adjustments were made to this value to convert to 2022 dollars as it is from a 2021 report with no information provided in the source document regarding dollar year of the value.

T/ The original value of $464 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Federal Reserve's Producer Price Index for Electric Power Generation.

U/ The original low end value of $16 billion in 2018 dollars was not adjusted and the original high end estimate of $28 billion in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

V/ The original values of $69 to $143 million in 2020 dollars were adjusted for inflation to 2022 dollars using the Federal Reserve's Producer Price Index for Electric Power Generation.

W/ The original value of $4 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

X/ The original values of 30 to 45 cents in 2019 dollars were adjusted for inflation to 2022 dollars using the Federal Reserve's Producer Price Index for Inland Water Freight Transportation.

Y/ The original values of 50 to 75 cents in 2019 dollars were adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics Producer Price Index for Rail Transportation of Freight and Mail.

Z/ The original value of $327.9 million in 2021 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AA/ The original value of $232 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries.

AB/ The original values were presented as annual totals in contemporary dollar years, which averaged to $124.3 million. The values in each year were adjusted separately for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator and then averaged.

AC/ The original values ($18,207,000; $15,566,000; $15,056,000; $26,696,000 in 2019 dollars) were summed to derive the total ($75,525,000 in 2019 dollars). These values were adjusted for inflation to 2020 dollars using the Bureau of Reclamation Operations & Maintenance Cost Index and further adjusted to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AD/ The original value of $32,154,000 in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AE/ The original values of $11,514,000 and $55,214,000 in 1998 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AF/ The original values of $10.8 million and $54.5 million in 1998 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AG/ The original value of $53 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AH/ The original value of $52 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AI/ The original value of $20 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AJ/ The original value of $1 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AK/ The original value of $400,000 in 2014 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AL/ The original value of $24,166,767 in 2009 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries.

AM/ The original value of $400,000 in 2014 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

AN/ The original value of $81.2 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries.

AO/ The original value of $27.4 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries.

AP/ The original value of $507 million in 1996 dollars was adjusted for inflation to 2001 dollars using the Consumer Price Index for All Urban Consumers, and further adjusted to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries. This combined adjustment was necessary since the Wages index only goes back to 2001.

AQ/ The values were also expressed in 2022 dollars using the Bureau of Economic Analysis GDP Price Deflator.

AR/ The original value of $94.5 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AS/ The original value of $962 million in 2021 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis GDP Price Deflator.

AT/ The original value of $669 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AX/ The original value of $32 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

AY/ This value was not adjusted for inflation since it is a government allocation.

AZ/ The original value of $6.2 million in 2018 dollars was adjusted for inflation to 2022 dollars using the average values of 1) the Bureau of Labor Statistics Producer Price Index for General Freight Trucking, and 2) the Bureau of Labor Statistics Producer Price Index for Rail Transportation of Freight and Mail. Present value costs were estimated using 50 years and a 2.25% discount rate.

BA/ The original values of $43 million and $49 million in 2018 dollars were adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator. To derive the annual value, the original study report timeframe of 20 years and discount rate of 2.75% was used.

Consistent with the rest of the study, to derive the present value of annual costs over 50 years, a discount rate of 2.25% was used.

BB/ The original values of $13 million and $15 million in 2018 dollars were adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads. To derive the annual value, the original study report timeframe of 20 years and discount rate of 2.75% was used. Consistent with the rest of the study, to derive the present value of annual costs over 50 years, a discount rate of 2.25% was used.

BC/ The original value of $5.9 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator. Consistent with the rest of the study, to derive the present value of annual costs over 50 years, a discount rate of 2.25% was used.

BD/ The original value of $16 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads. Consistent with the rest of the study, to derive the present value of annual costs over 50 years, a discount rate of 2.25% was used.

BE/ The original values of $4 million and $10 million in 2019 dollars were adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads. Consistent with the rest of the study, to derive the present value of annual costs over 50 years, a discount rate of 2.25% was used.

BF/ The original values of $30 million, $36 million, $2.1 million, and $2.5 million in 2019 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BG/ The original value of $4.9 million in 2014 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BH/ The original value of $25 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BI/ Matched to BE

BJ/ The original values of $48 million and $192 million in 1999 dollars were adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads.

BK/ The original values of $84 million and $100.7 million in 1999 dollars were adjusted for inflation to 2022 dollars using the Bureau of Reclamation's Construction Cost Index for Primary Roads.

BL/ The original values of $18,908,544 and $37,817,088 in 2019 dollars were adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics Producer Price index for Rail Freight and Mail.

BLL/ The original value of $6.2 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics Producer Price index for Rail Freight and Mail.

BM/ The original value of $943.1 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BP/ Matched with reference Z

BQ/ The original value of $632 million in 2021 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis GDP Price Deflator.

BR/ The original value of $232 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics Producer Price Index for Wages and Salaries.

BS/ The original range of $12,577,000 to $16,953,343 in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis GDP Price Deflator.

BT/ The original value of $67.04 million in 1998 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BU/ The original value of $12 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BV/ The original value of $594,000 in 1998 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BW/ The original value of $30 million in 1998 dollars was adjusted for inflation to 2001 dollars using the Consumer Price Index for All Urban Consumers, and further adjusted to 2022 dollars using the Bureau of Labor Statistics Producer Price Index for Wages and Salaries. This combined adjustment was necessary since the Wages index only goes back to 2001.

BX/ The original value of $290 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Consumer Price Index for All Urban Consumers.

BY/ The original low end value of $1 billion in 2018 dollars was not adjusted and the original high end estimate of $4 billion in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

BZ/ The original value of $535 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index. Assuming constant annual costs over 50 years, present value was calculated using a 2.25% discount rate.

CA/ The original value $270 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CB/ The original annualized value of $400 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index. Assuming annualized costs are constant over the 50 year analysis period, present value over 50 years was calculated using a 2.25% discount rate.

CC/ The original annualized value of $464 million in 2017 dollars was not adjusted for the low end estimate in 2022 dollars and for the high end estimate was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index. Assuming annualized costs are constant over the 50 year analysis period, present value over 50 years was calculated using a 2.25% discount rate.

CD/ The original annualized value of $540 million in 2019 dollars was not adjusted for the low value and for the high value was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index. Assuming constant annual costs over 50 years, present value was calculated using a 2.25% discount rate.

CE/ Although the original values were in 2020 dollars, no adjustments for inflation were made as this was a 2022 analysis and the report authors recommended no adjustments to values for inflation.

CF/ The original annualized value of $978 million in 2019 dollars was converted to a present value using the original source's terms (50-year time period and a 2.875% discount rate). This value was not updated for inflation due to ambiguous trends in the cost of constructing renewable energy projects.

CG/ The original values that comprised this sum were $238,727,000 and $8,956,000 in 2018 dollars. These were adjusted for inflation to 2020 dollars using the Bureau of Reclamation Operations & Maintenance Cost Index and further adjusted to 2022 dollars using the Consumer Price Index for All Urban Consumers.

CI/ The original value of $94.5 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CJ/ The original value of $144.8 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record's Construction Cost Index.

CK/ The original value of $23.8 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

CL/ The original value of $3.5 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Consumer Price Index for All Urban Consumers.

CM/ Matched with reference W

CN/ The original value of $108.9 million in 2017 dollars was adjusted for inflation to 2022 dollars using the Consumer Price Index for All Urban Consumers.

CO/ The original value of $347 in 2017 dollars was adjusted for inflation to 2022 dollars using the Consumer Price Index for All Urban Consumers.

CP/ The original value of $148 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CQ/ The original value of $162,738,000 in 1998 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CR/ The original value of $128,743,000 in 1998 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CS/ The original value of $1.36 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Labor Statistics' Employment Cost Index for Wages and Salaries.

CT/ The original value of $50.8 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record's Construction Cost Index.

CU/ The original value of $82.3 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record's Construction Cost Index.

CV/ The original value of $12.2 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record's Construction Cost Index.

CW/ The original value of $2.7 million in 2018 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record's Construction Cost Index.

CX/ The original value of $358.5 (the sum of $64.04 million and $29.148 million) in 1998 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

CY/ Matched to reference R

CZ/ Original value of $786 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

DA/ Original values of $55 million to $86 million in 2019 dollars were adjusted for inflation to 2022 dollars using the Engineering News-Record Construction Cost Index.

DB/ Original present values over a 50-year timeframe of $11.2 billion to $19.6 billion in 2022 dollars were adjusted based on the use of a 2.25% discount rate instead of the original 3% discount rate.

DC/ Original present values over a 50-year timeframe of $42 billion to $77 billion in 2022 dollars were adjusted based on the use of a 2.25% discount rate instead of the original 3% discount rate.

DD/ Original present values over a 16-year period of $15 billion were adjusted based on the use of a 2.25% discount rate instead of the original 2% discount rate.

DE/ It is unclear if the original annual recurring value of $2.5 billion in 2045 is in 2022 or 2045 dollars; the report notes that an annual inflation rate of 2% is used. The estimate of $2.5 billion in 2045 dollars assuming a 2% discount rate would equal $1.6 billion in 2022 dollars.

DF/ In addition to the $14.7 billion during the first 16 years, an additional $26.8 billion to $42.2 billion of present value costs was estimated based on an annual recurring cost of $1.6 billion to $2.5 billion from years 17 to 50 of the analysis time period.

DG/ This value is based on the sum of present values calculated over 50 years using a 2.25% discount rate for each of the annualized values in 2022 dollars presented in the CRSO EIS, plus turbine replacement costs from EcoNorthwest's report *Lower Snake River Dams Economic Tradeoffs of Removal*. The present values used in our sum of present value costs of continuing to operate the dams are: $2.5 billion for operations and maintenance costs in 2022 dollars, and $1.1 billion in capital costs.

DH/ These values are calculated using the annual values of $30 billion and $42 billion over 50 years using a 2.25% discount rate.

DI/ The original value of $105 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

DJ/ This value was calculated using an annual value of $116 million over 50 years using a 2.25% discount rate.

DK/ The original value of $34 million in 2019 dollars was adjusted for inflation to 2022 dollars using the Bureau of Economic Analysis' GDP Price Deflator.

DL/ This value was calculated using an annual value of $37.4 million over 50 years using a 2.25% discount rate.

Appendix D: Summary of Public Comments on Draft Report

This appendix provides a high-level summary of the major themes of public comments received on sections of the draft report. The draft report was available for public review from June 9, 2022, through July 11, 2022. Public comments were collected online and by mail. Online comments were provided through a form at www.lsrdoptions.org, and comments by mail were submitted electronically (email to info@lsrdoptions.org) or by paper mail.

By the end of the public comment period, the consultant team received approximately 1,769 online form submissions, 22 comments via paper mail, and approximately 65,000 emails and attachments. The public could submit as many comments as desired within the 30-day comment period, and as such the number of responses does not necessarily represent the number of individual commenters.

Section 2. Change in the Lower Snake River and the Columbia River System Is Inevitable

Supporters of dam breaching requested that the final report include more information on the anticipated ongoing and future costs of operating and maintaining the LSRD. This was meant to provide a point of comparison, albeit not "apples-to-apples," of the estimated costs of replacing or mitigating the services provided by the LSRD.

Supporters of maintaining the LSRD did not agree with the premise of the section, believing that additional operational measures, like those described in MO4 in the 2020 CRSO EIS, would not be implemented if the dams were to stay in place or that federal court decisions would likely limit operations in the future to protect salmon and steelhead populations. These commenters believe the LSRD will be more important in the future for the region's energy needs and salmon can coexist with the dams.

Section 3. Dam Breaching and Removal: Definition, Assumptions, and Costs

Use of different reports

Both supporters of dam breaching and supporters of maintaining the LSRD noted that the draft report compares data, results, and conclusions from various sources with the CRSO EIS, but these sources should not be considered equal. They noted that the EIS is a multi-agency report that was publicly reviewed, whereas other references cited in the draft report were commissioned from advocacy organizations with an interest in a particular outcome. They also suggested various other reports and analyses to consider including as part of the draft report.

Downriver impacts

Supporters of maintaining the dams cited previous examples of reservoir drawdowns (for example, a 1992 USACE test drawdown) that resulted in negative impacts for salmon and infrastructure. Commenters also noted that the draft report does not address the impact of dam removal on the energy and transportation sectors in the State of Oregon. Supporters of dam breaching cited recent examples like the Elwha dam for how quickly a river can recover and the immediate benefits for salmon and other species.

Additional services

Supporters of maintaining the dams noted that the dams provide additional services not discussed in the draft report, such as flood control and water supply for regional wildland firefighting.

Miscellaneous

Various miscellaneous comments on the draft report did not fit into the previous categories. This included disagreement with the draft report's statements around federal authorization for dam removal, and a suggestion to better define some of the terminology in the draft report. In addition, some suggested permitting for dam removal and permitting for all associated construction activities related to infrastructure should be listed as a barrier to dam breaching.

Additional analysis

Commenters provided ideas for additional analyses related to dam breaching and removal assumptions and costs. This includes analyses regarding the long-term cost of maintaining the status quo, including sediment controls costs, cost of maintaining the dams, and the estimated LSRD lifespan. Others suggested analyzing impacts to biodiversity and carbon sequestration if the dams are breached or retained. Supporters of maintaining the dams believe the costs of breaching were underestimated and much more engineering and analysis is required.

Section 4. LSRD Impacts to Species and Tribes Drive Interest in Breaching Option

Salmon and aquatic species

Comments on this section varied greatly around the degree that commenters believe dam breaching would benefit salmon. Comments also varied greatly on what the most effective use of funds would be for Columbia Basin salmon recovery.

Supporters of maintaining the dams suggested that dams and salmon can coexist, noting that the survival rate at each dam is above 95% and that other issues impacting salmon such as predation, harvest and changes to the ocean environment should be given more attention than dam breaching. Technical studies were referenced that disagree with the conclusion that the dams cause significant delayed mortality and therefore dam breaching would not achieve estimated benefits for salmon and steelhead. Supporters of maintaining the dams argued investing in other measures would have a greater benefit for salmon such as increased hatchery production, habitat restoration in both the ocean and upland environment, and increased predator management. Addressing ocean conditions should be prioritized for study, given salmon spend most of their life cycle in the ocean.

Supporters of dam breaching suggested that breaching is the best approach for preventing the extinction of the species that inhabit the Snake River Basin, noting the link between Snake and Columbia Basin Chinook salmon and the Southern Resident orca, pointing to new studies that show Southern Residents have adjusted their feeding patterns away from Puget Sound salmon stocks and are now relying more on Columbia and Snake River salmon throughout the year. Supporters of dam breaching noted the $24 billion already spent on BPA's Fish and Wildlife mitigation program in the Snake and Columbia Rivers, and that despite this level of investment many salmon stocks are at similar abundance levels as when they were first listed under the Endangered Species Act. Supporters of dam breaching also pointed to diminishing wild salmon abundances in the Snake River Basin and believe that current operations with the dams in place will lead to extinction. Supporters of dam breaching suggested the draft report understated the non-quantifiable ecosystem and natural process improvements that would occur with dam breaching, such as cooler water temperatures, improved food supply, and reduced predation.

Tribes

Comments on tribal nations primarily addressed how the dams have led to social and environmental justice challenges for tribes in the Snake River Basin. Many commenters stressed the spiritual and cultural benefits that dam breaching would provide to the tribes, including the ability to reconnect with their traditional spiritual and fishing sites that are currently inundated. Comments suggested, at a minimum, tribes should be involved in any breaching and post-breaching activities, if not leading these efforts. Supporters of dam breaching suggested the report downplayed the impacts the dams have had on tribes downriver in the Lower Columbia and along the coast due to the loss of salmon.

Fisheries

Supporters of dam breaching suggested the report understates the importance that salmon fisheries have on rural communities across the region and suggested additional analysis on the impact of salmon declines on these rural communities. Supporters of maintaining the dams questioned the impact of fisheries on population survival.

Additional analysis

Commenters provided ideas for additional analyses related to salmon and aquatic species. This includes additional analysis of a phased approach to dam breaching, to see how fish abundances react to each dam that is breached. Commenters also requested additional cost analysis on natural resource or ecological based actions associated with breaching like modified hatchery operations, habitat improvement actions, adjustments to harvest management, species reintroductions, and monitoring. Commenters requested additional environmental impact analysis be done on additional emissions impacts on salmon because of breaching. Finally, supporters of maintaining the LSRD recommended additional analyses on alternative restoration activities to breaching like additional spill, fish ladder improvements, habitat restoration, predator management, fish transport, and increased hatchery production.

Section 5. Navigation and Transportation of Grain and other Commodities

Data and data analysis

A wide range of comments were related to the data supplied in the transportation section, both from dam breaching supporters and supporters of maintaining the dams. These included suggestions to provide more precise data on wheat shipments to Pacific ports, clarify the percentage of barge and rail shipments of commodities, and update the calculated volume of commodities shipped on the lower Snake River. Dam breaching advocates also suggested the draft report reference long-term shipping trends on the lower Snake River.

Reports/references cited or suggestions for additional reports/references to include

Dam breaching advocates and supporters of maintaining the dams suggested additional reports and other references to include or cite in the draft report, to provide more clarity around transportation impacts and costs associated with the dams. As with comments on other sections of the draft report, some commenters suggested discounting or removing references provided by advocacy organizations with a vested interest in a particular outcome.

Downriver impacts

Supporters of maintaining the dams noted that dam removal could have additional impacts, and these should be noted in the report. For example, dam removal could negatively impact navigation immediately downriver in the McNary pool, disrupting both upriver and downriver commodity shipments to and from Pasco.

Emissions and safety impacts

Supporters of maintaining the dams suggested including information on the potential increase in CO_2 and other GHG emissions because of dam breaching. They argued the report does not sufficiently capture the impacts to public safety that would occur due to dam breaching. Supporters of breaching noted that the trend toward transportation electrification will mitigate emissions impacts.

Economic impacts

Supporters of maintaining the dams suggested various economic impacts that the draft report either does address or does not sufficiently address. This includes lost value of farmland and agricultural production from increased transportation costs, employment impacts at the Ports of Whitman County, increased fuel taxes, and loss of recreational boating and tourism.

Infrastructure considerations

Cost and feasibility of transportation infrastructure changes were common themes from public comments, especially from supporters of maintaining the dams. Commenters stated that it will be prohibitively expensive to upgrade regional transportation infrastructure after dam removal (including shoreline infrastructure adjacent to the restored river channel), and that lower Columbia ports lack capacity to accommodate increased vehicle traffic.

Railroads

Dam breaching supporters and supporters of maintaining the dams discussed the feasibility of shifting cargo movement from barges to primarily short line and mainline railroads. Supporters of maintaining the dams asserted that the cost to build the necessary rail infrastructure will be extremely expensive and that railroads will inevitably increase prices in a non-competitive environment. Other commenters stated that a significant amount of short line rail infrastructure has been railbanked or abandoned in Eastern Washington and, although it will be expensive, resurrecting this infrastructure to provide sufficient service to grain producers is feasible.

Miscellaneous comments

Various miscellaneous comments on the draft report do not fit into the previous categories. This included a comment that the report should discuss climate change impacts on grain production.

Additional analysis

Commenters provided ideas for additional analyses related to navigation and transportation of grain and other commodities. This includes more detailed analysis of taxpayer and ratepayer subsidies for barge transportation and more in-depth feasibility analysis of transportation impacts.

Section 6. Irrigated Agriculture

Data and data analysis

Supporters of maintaining the dams suggested the report underestimated the total number of acres irrigated and production value of irrigated agriculture along the lower Snake River. Commenters also noted a lack of analysis of lost revenue from shifting irrigated agriculture to dryland agriculture.

Climate change/water availability

Commenters noted a lack of climate change considerations in the report section on irrigated agriculture. Commenters emphasized the need for more understanding of how irrigated agriculture may shift in the future, such as increased use of groundwater versus surface water diversion, and how breaching the LSRD may influence these shifts.

Broader regional and economic impacts

Supporters of maintaining the dams were interested in knowing more about broader regional impacts as a result of changing groundwater elevation and water supply availability. Additionally, commenters wanted more information on how breaching would impact irrigators downstream from the LSRD in the lower Columbia River basin, in particular sedimentation impacts.

Supporters of maintaining the dams requested more information on how farmers would be impacted by increased electrical use as a result of water levels lowering, and whether there would be financial support for irrigators to compensate them. Commenters wanted additional analysis on the full impact on irrigated agriculture for the state, national and global economy, and food security.

Additional analysis

Commenters provided ideas for additional analyses related to irrigated agriculture. This includes analyses regarding impacts on non-irrigated agricultural interests such as dairy production, increased costs to producers when irrigation pumps require greater electricity, greater understanding of the impact to private and municipal wells, and whether impacts to a diminished water table would impact future agricultural irrigation. Others suggested additional analysis on how climate resiliency for farmland can be addressed in the future.

Section 7. Energy Replacement

Existing services

Supporters of maintaining the dams, and several energy experts suggested that the report stated the existing services and benefits of the LSRD in a manner that did not reflect their full value to the region. They recommended emphasizing the capacity of the dams above their nameplate generation, and their ability to provide year-round dispatchable energy, including during cold snaps and extreme heat periods. The value for transmission and grid resiliency was also pointed out by commenters.

Supporters of dam breaching emphasized the small percentage of the LSRD's annual average production and that the dams' peak production period is during the spring when the hydrosystem has an abundance of energy. They also suggested that the LSRD provided a significant role during recent cold snaps and extreme heat events.

Actions needed to replace or improve services

Supporters of maintaining the LSRD stressed the need for the clean base-load power that hydropower provides to meet future clean energy goals, and hydropower's ability as a balancing resource to integrate intermittent renewables like wind and solar into the grid. They were also concerned about the ability to maintain grid stability if the grid relies on more intermittent resources. There was doubt that emerging technologies will become commercially available to replace the energy and services provided by the LSRD in the timeframe of breaching. Supporters of maintaining the LSRD were concerned about the environmental impact of breaching, citing raw material availability issues that could be associated with the renewable resources necessary to replace the energy and services provided by the LSRD. Some were wary of additional solar and wind development in Eastern Washington and noted local resistance to recent renewable development in the region. There were concerns with other potential replacement resources like small nuclear reactors. Supporters of maintaining the LSRD were critical of the reports utilized to project potential resource replacement for the LSRD and believed studies that projected the ability to replace the LSRD did not have the same level of robustness as the 2020 CRSO EIS.

Supporters of dam breaching believe that existing technologies can provide the energy and services that the dams currently provide. However, there was disagreement on the peaking capabilities of current battery technology, with supporters of dam breaching believing it is sufficient, while others noting that current battery technology is insufficient to replace multi-day dispatchable capacity, especially given Pacific Northwest climate patterns. Supporters of dam breaching believe that an optimized replacement portfolio could bring additional benefits to the grid by providing power during current lower generation periods in the late summer and winter, as opposed to during the spring runoff.

Additional analysis

Commenters provided ideas for additional analyses related to energy replacement. This includes additional analysis on LSRD breaching and potential impacts of meeting regional clean energy goals. Commenters also requested analysis on region-wide siting for renewable energy projects that includes cultural and natural resource impacts. Other suggestions included a comprehensive power analysis to address the implications of dam removal on grid reliability, transmission costs, and grid stability across the region, considering the many other drivers for resource additions over the next 30 years. Commenters also suggested analysis of the feasibility of a phased or incremental approach to dam breaching to allow time for emerging technologies and innovation to play the largest possible role in meeting current and future energy needs.

Section 8. Tourism and Recreation

Impacts to existing tourism and recreation system

Supporters of maintaining the LSRD suggested the draft report understated the impact dam breaching would have on river communities along the Snake River and that impacts would be felt well beyond Lewiston, Clarkston, and the broader region. Some suggested that existing parks and other recreational facilities and services that would be closed or modified by dam breaching, such as the loss of the local cruise boat industry, would have reverberating impacts on jobs, local economies, industry, and community beyond what was stated in the report. Other commenters were skeptical of projected increases in salmon recovery achieved through breaching and how that could translate to a growing sportfishing industry.

Recreational benefits from dam breaching

Supporters of dam breaching suggested the report should more strongly state the potential for enhanced recreational opportunities and the growth of a new tourism industry built around a free-flowing river, such as a growing sportfishing industry, revitalization of the Lewiston-Clarkston waterfront, and new river-rafting opportunities. Other commenters suggested the report should state that dam breaching would benefit sportfishing and other types of recreation in the upper Snake Basin because flow augmentation presumably would no longer be required. For example, if 427,000 acre-feet of water from the upper Snake Basin is no longer required to help speed juvenile salmon and steelhead through the lower Snake River reservoirs, cold water fisheries in places like the Snake River in Wyoming and the Henrys Fork, South Fork Snake River, and Teton River in eastern Idaho could benefit significantly.

Additional analysis

Commenters provided ideas for additional analyses related to recreation. This includes economic analyses of how the anticipated benefits of restoring the lower Snake River to a free-flowing river would compare to other existing river recreation-based economies. Other commenters suggested more detailed analysis of the potential socio-economic impacts of dam removal (or keeping the dams in place) for upstream tributaries like the Salmon, Lochsa and Selway Rivers.

Section 9. Economic Impacts and Opportunities

Salmon economics

Supporters of dam breaching suggested the draft report should have more information on salmon-related economics. For example, some suggested the draft report lacked information on how the loss of salmon to date has impacted jobs and income for ocean-based fisheries.

Additional analysis

Commenters provided ideas for additional analyses related to economic impacts and opportunities. This includes analysis on how breaching the LSRD would potentially impact property values along the Snake River, and how this would impact city tax revenue, particularly in poor areas. Others suggested doing an analysis of the existence value or passive value of restoring the lower Snake River, similar to an assessment done for the Klamath River Basin in advance of dam removal. Others recommended that the report should include an analysis of impact of fish declines on small towns across the region and how increased fishing would benefit economies in Washington, Idaho and Oregon.