US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

APRIL 2025

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Lead Agency
U.S. Army Corps of Engineers
Portland, Oregon District

Cooperating Agencies
Bonneville Power Administration
Confederated Tribes of Grand Ronde Community of Oregon
Confederated Tribes of Siletz Indians
Confederated Tribes of the Warm Springs Reservation of Oregon
National Marine Fisheries Service
Oregon Department of Agriculture
Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife
Oregon Water Resources Department
U.S. Bureau of Reclamation
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service

Proposed Action

The Proposed Action is to continue operations and maintenance of the Willamette Valley System for specific, authorized purposes. Responsibility for operating each dam and reservoir and the overall system was directed to the U.S. Army Corps of Engineers by Congress in authorizing legislation. Consequently, the Proposed Action is to continue with this authorizing legislation.

Affected Areas
State: Oregon
Counties: Benton, Lane, Linn, and Marion Counties

Contact for Further Information

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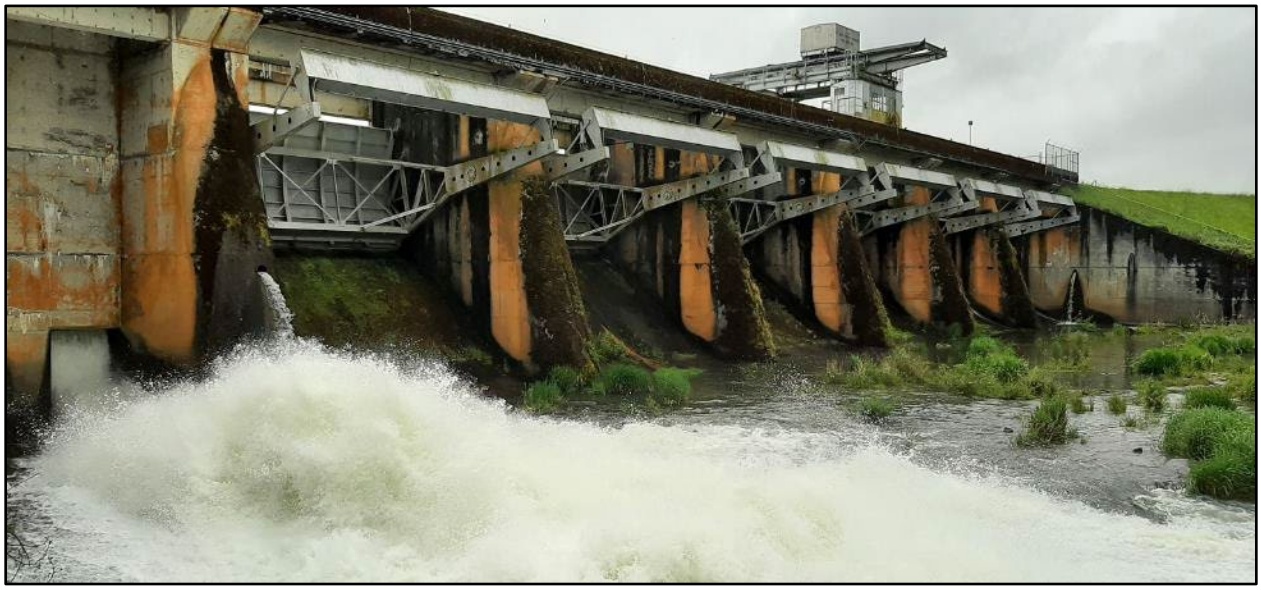
Cover Photograph: Cottage Grove Reservoir
Unknown Photo Credit (USACE Media Images Database)

Federal Permits, Licenses, and Entitlements to be Obtained to Implement the Proposal

There are no permitting, licensing, or entitlement requirements related to the proposal under review. The proposal has been reviewed programmatically in this Environmental Impact Statement. Any permitting, licensing, or entitlement requirements will be identified in subsequent environmental reviews as applicable and as consistent with the National Environmental Policy Act and U.S. Army Corps of Engineers Procedures for Implementing the National Environmental Policy Act.



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Fern Ridge Dam was the first of 13 dams to be built in the Willamette Valley System in 1941.

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Chapters and sections are individual files that contain a table of contents, if applicable.

APPENDICES

ABSTRACT

The U.S. Army Corps of Engineers (USACE), Portland, Oregon District prepared this Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA), 42 U.S.C. 4321, and USACE NEPA Implementing Regulations, 33 CFR Part 230. Twelve Cooperating Agencies and interested tribes provided information and review throughout the EIS process.

Public involvement during the scoping process and public comment on the Draft EIS (DEIS) informed the Final EIS (FEIS). Public scoping began on April 1, 2019, with publication of a Notice of Intent in the Federal Register (84 FR 12237). The DEIS public comment period began on November 22, 2022, for a 55-day period noticed in the Federal Register (87 FR 72482). USACE announced a 35-day extension in the Federal Register on January 13, 2023 (88 FR 2357). The full 90-day public comment period closed on February 23, 2023. The Public Comment Scoping Report is in Appendix P.

The NEPA process for this EIS began in 2019, prior to any revisions to the Council on Environmental Quality's (CEQ) 1978 implementing NEPA regulations. Therefore, this EIS was initially subject to, and complies with, the 1978 NEPA implementing regulations as amended. Additionally, USACE applied the most current CEQ guidance on use of programmatic NEPA reviews, December 18, 2014. CEQ rescinded all of its implementing regulations on April 11, 2025. Several Executive Orders and related guidance regarding climate change analyses were also rescinded 2 months prior to finalization of this EIS. Consequently, references to the CEQ regulations and analyses of greenhouse gas emissions, social cost of carbon, and climate change were not removed in the FEIS to avoid delay in decision-making and the significant time and resources required for document revisions.

The Proposed Action is to continue operations and maintenance of the Willamette Valley System for specific, authorized purposes. Responsibility for operating each dam and reservoir and the overall system was directed to USACE by Congress in authorizing legislation. Consequently, the Proposed Action is to continue with this authorizing legislation.

USACE manages a complex operation in western Oregon's Willamette Valley that includes storing and releasing water from 13 reservoirs to balance various needs and demands throughout a given year. Operations and maintenance of these 13 reservoirs and dams are coordinated to function as the Willamette Valley System. Water needs and demands are balanced through the eight Congressional authorized uses that include flood risk management, hydropower, fish and wildlife, recreation, navigation, irrigation, municipal and industrial water supply, and water quality.

Prior to completion of this FEIS, it had been over two decades since USACE conducted a NEPA review of the Willamette Valley System. Since the 1980 EIS was published, operations have been modified and structural measures for fish passage and temperature control have been implemented to improve conditions for ESA-listed fish species. Considerable information has

become available since the 1980 EIS was completed, which has been incorporated into the existing conditions and analyses in this FEIS.

In addition to the No-action Alternative, seven action alternatives have been analyzed. The alternatives are distinguished by operational or structural measures, including flow, water quality, and fish passage. Measures common to all action alternatives include gravel augmentation and operation and maintenance of adult fish facilities among other measures.

Painting by Lee Jensen, USACE Employee, 1991-2001 (USACE Portland District Media Images).

ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
7dADM	7-day average daily maximum
A	
A.D.	Anno Domini
ACM	asbestos-containing materials
ALBO	Mainstem Willamette River at Albany
aMW	average megawatt
ARPA	Archaeological Resources Protection Act
B	
BCLO	Downstream of Big Cliff and Detroit Dams
BLM	U.S. Bureau of Land Management
BMP	Best Management Practices
BOR	U.S. Bureau of Reclamation
B.P.	years Before the Present
BPA	Bonneville Power Administration
C	
CAA	Clean Air Act
CBSA	Core-based Statistical Area
CCS	Cross Cascades South
CEJST	Climate and Environmental Justice Screening Tool
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGRO	Downstream of Cougar Dam
CH_3Hg	methylmercury
CO	carbon monoxide
CO2	carbon dioxide
CTCLUSI	Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw
CTGR	Confederated Tribes of Grand Ronde
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act

D	
dBA	a-weighted decibel
DEXO	Downstream of Dexter Dam
DOE	U.S. Department of Energy
DPS	distinct population segment
E	
EA	Environmental Assessment
E-flow	Environmental Flow
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
F	
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FSS	floating screen structure
FMWQT	Flow Management and Water Quality Team
G	
GIS	Geographic Information Systems
H	
HCRO	Downstream of Hills Creek
HEC-RAS	Hydrologic Engineering Center River Analysis System
HEC-ResSim	Hydrologic Engineering Center Reservoir Simulation
Hg	mercury
HGMP	Hatchery Genetic Management Plan
HTRW	hazardous, toxic, and radioactive waste
I	
IES	Issue Evaluation Study
IRRMs	Interim Risk Reduction Measures
K	
Kaf	thousand acre-feet
Km^2	kilometers squared
kV	kilovolt
KW	kilowatt
kWh	kilowatt hour

L	
LCOG	Levelized Cost of Generation
LOLP	loss of load probability
M	
Maf	million acre-feet
mg/kg	milligrams per kilogram
MOP	minimum operating pool
MOU	Memorandum of Understanding
mph	miles per hour
MPSFs	Minimum Perennial Streamflows
MSA	Metropolitan Statistical Area
MSL	mean sea level
MW	megawatt
MWh	megawatt hour
N	
NAA	No-action Alternative
NEPA	National Environmental Policy Act
ng/L	nanograms per Liter
NGO	non-governmental organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NWFSC	Northwest Fisheries Science Center
O	
O3	ozone
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODLCD	Oregon Department of Land Conservation and Development
ODOT	Oregon Department of Transportation
ODWS	Oregon Drinking Water Services
OEA	Oregon Office of Economic Analysis
OED	State of Oregon Employment Department
OHWM	Ordinary High Water Mark

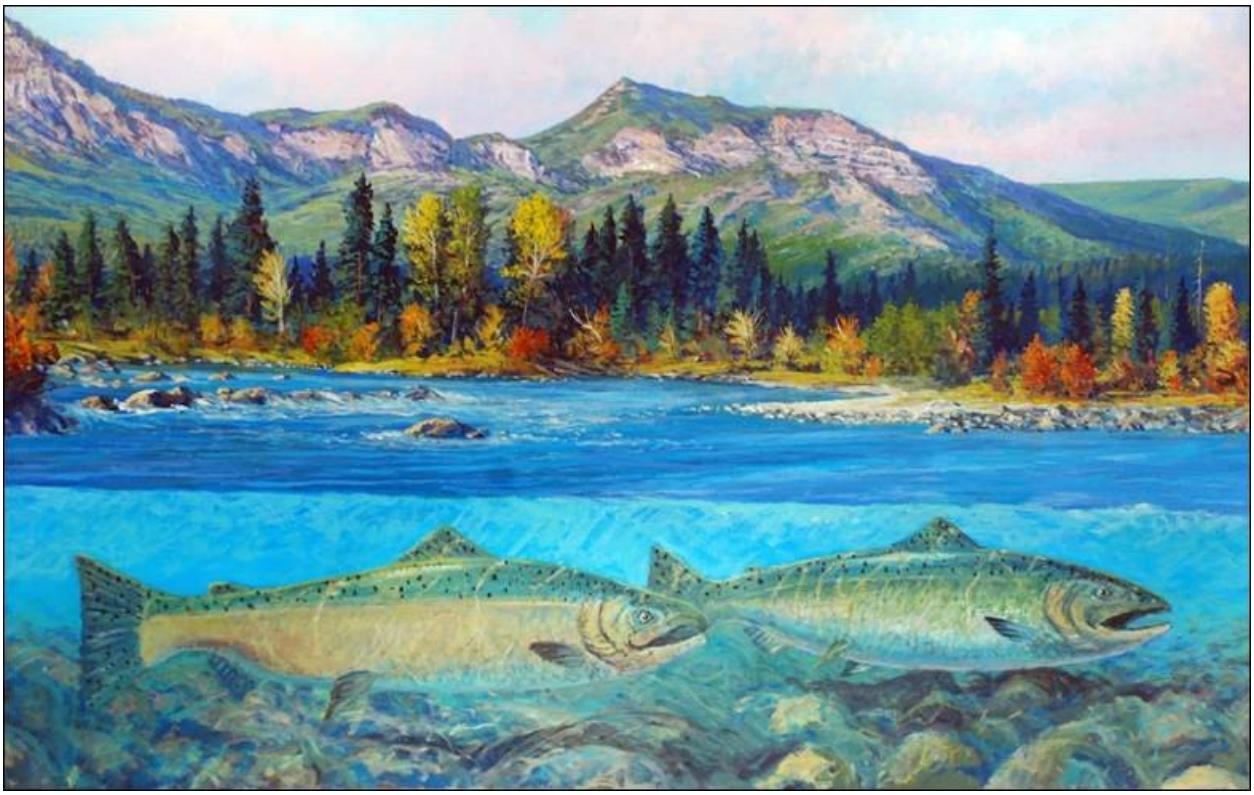
OPRD	Oregon Parks and Recreation Department
ORS	Oregon Revised Statues
OSHA	Occupational Safety and Health Administration
OWRD	Oregon Water Resources Department
P	
Pb	lead
PCBs	polychlorinated biphenyls
PFMC	Pacific Fishery Management Council
pH	potential of hydrogen or acidity
pHOS	proportion of hatchery-origin spawners
PIT	passive integrated transponders
PM	particulate matter
pNOB	proportion of natural-origin brood
pp.	pages
ppb	parts per billion
ppm	parts per million
PUDs	Public Utility Districts
R	
RCRA	Resource Conservation and Recovery Act
RECONS	Regional Economic System
RED	Regional Economic Development
RFFA	reasonably foreseeable future action
RM	river mile
RO	regulating outlet
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
S	
SHPO	State Historic Preservation Office
SLMO	Mainstem Willamette River at Salem
SO_2	sulfur dioxide
SOA	South of Allston
SSFO	Downstream of Foster and Green Peter Dams
T	
TDG	total dissolved gas
THg	total mercury
TMDL	total maximum daily load
TRGs	tolerable risk guidelines

U	
U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USDOT	U.S. Department of Transportation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWR	Upper Willamette River
V	
VOCs	volatile organic compounds
VRM	Visual Resource Management
VSP	Viable Salmonid Population
W	
WATER	Willamette Action Team for Ecosystem Restoration (also WATER forum)
WFPOM	Willamette Fish Passage Operations & Maintenance
WLCTRT	Willamette/Lower Columbia Technical Recovery Team
WRDA	Water Resources Development Act
WVS	Willamette Valley System
WWSS	Willamette Water Supply System

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

FINAL ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY



Painting by Lee Jensen, USACE Employee, 1991-2001 (USACE Portland District Media Images).

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The U.S. Army Corps of Engineers (USACE), Portland, Oregon District prepared this Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA), 42 U.S.C. 4321, and USACE NEPA Implementing Regulations, 33 CFR Part 230. Twelve Cooperating Agencies and interested tribes provided information and review throughout the EIS process.

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Unknown Photo Credit (USACE Media Images Database)
McKenzie River.

2 - Background

The United States Congress, through the Flood Control Act of 1938 and subsequent acts, authorized USACE to construct, operate, and maintain a system of dams, reservoirs and bank protection revetments primarily for flood control in the Willamette River Basin (Figure ES-1). USACE operates and maintains the Willamette Valley System (WVS) as a system of 13 dams and reservoirs and associated hatchery and fish collection facilities:

- Hills Creek, Lookout Point, Dexter, and Fall Creek Dams and Reservoirs in the Middle Fork Willamette River Subbasin
- Dorena and Cottage Grove Dams and Reservoirs in the Coast Fork Willamette River Subbasin
- Cougar and Blue River Dams and Reservoirs in the McKenzie River Subbasin
- Fern Ridge Dam and Reservoir in the Long Tom River Subbasin
- Detroit and Big Cliff Dams and Reservoirs on the North Santiam River
- Green Peter and Foster Dams and Reservoirs in the South Santiam River Subbasin

Congress authorized eight purposes for the WVS, flood risk management, hydropower, fish and wildlife, recreation, navigation, irrigation, municipal and industrial water supply, and water quality. To meet these purposes, the WVS stores and releases water from the 13 reservoirs to balance needs and demands for water resources.

Other Federal agencies have responsibilities for the WVS, including the Bonneville Power Administration, which markets and transmits the electrical power generated by the eight hydropower-producing dams, and the U.S. Bureau of Reclamation, which markets water for irrigation purposes to users within the Willamette River Basin.

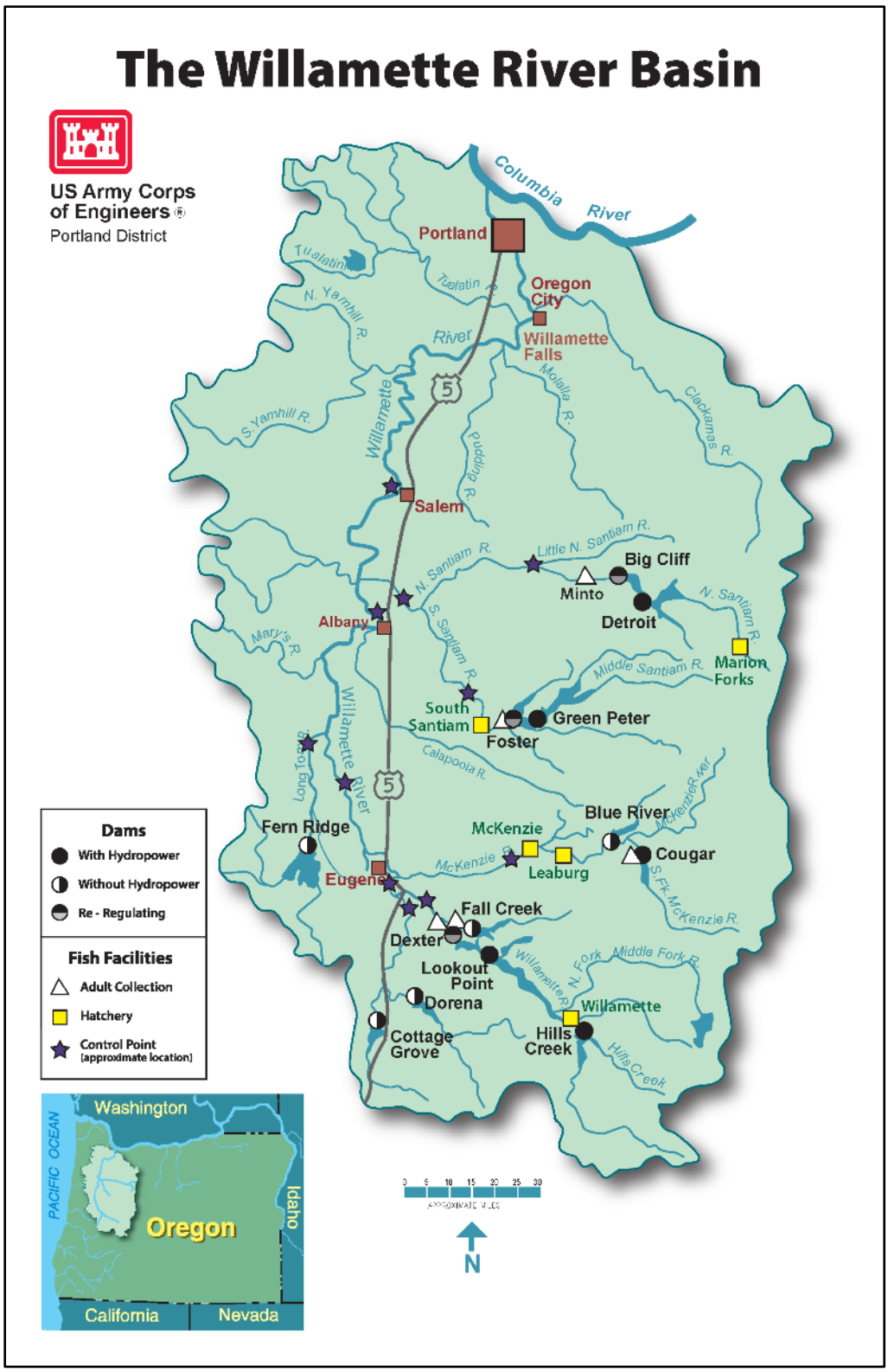

Figure ES-1. Willamette Valley System Dams, Reservoirs, Adult Fish Facilities, and Fish Hatcheries.

2.1 Court-ordered Injunction Measures

On September 1, 2021, the U.S. District Court for the District of Oregon issued an injunction in *NEDC v. USACE.*[1] The order requires USACE to implement interim actions intended to improve conditions for fish passage and water quality in the WVS to avoid irreparable harm to ESA-listed salmonids. These actions remain in effect until the completion of the Section 7 ESA consultation with NMFS and USFWS.

The Court ordered operational changes and three structural modifications to existing dams and reservoirs (Table ES-1). The three structural modifications have undergone, or are currently undergoing, separate site-specific NEPA processes to assess the direct, indirect, and cumulative impacts of their effects on the human environment.

USACE is reviewing the direct and indirect effects of these construction actions under separate NEPA compliance processes; therefore, they are not assessed in this EIS.

Table ES-1. Court-ordered Structural Improvements and Modifications.

Dam	Description	Status
Dexter	Upgrade the Dexter adult fish facility.	As of April 2025, construction is ongoing.
Big Cliff	Determine whether operational measures are sufficient to maintain acceptable total dissolved gas levels below Big Cliff Dam and, if not, design and construct a structural solution for mitigating excess total dissolved gas levels during spill operations.	USACE determined that operational fixes are not sufficient and developed a schedule for design and construction of rock weirs to further reduce total dissolved gas.
Cougar	Determine whether structural improvements/modifications to regulating outlets need to be made to ensure safer fish passage and to reduce total dissolved gas levels. If so determined, design and construct a structural solution.	The Court established Expert Panel recommended resurfacing the regulating outlet chute. Completed in 2023.

3 - Proposed Action

The Proposed Action is to continue operations and maintenance of the Willamette Valley System (WVS) for specific, authorized purposes. Responsibility for operating each dam and reservoir and the overall system was directed to USACE by Congress in authorizing legislation.

[1] *Northwest Environmental Defense Center, et al. v. United States Army Corps of Engineers, et al.*, No. 3:18-cv-00437-HZ (D. Or. September 1, 2021).

Consequently, the Proposed Action is to continue with this authorizing legislation. The Proposed Action would be implemented over a 30-year timeframe.

4 - Purpose and Need for the Proposed Action

The purpose and need for the continued operations and maintenance of the WVS is to operate the system in accordance with the eight Congressionally authorized purposes as detailed in Section 1.10, Congressionally Authorized Purposes, and in compliance with the Endangered Species Act (ESA) and all other applicable treaties, laws, and regulations.

USACE did not consider potential alternatives and associated measures inconsistent with the purpose and need for the Proposed Action. The seven action alternatives analyzed in detail would ensure continued compliance with Congressional authorizations. The analysis area to address potential impacts under the alternatives is the Willamette River Basin.

USACE must operate and maintain the WVS for specific purposes but cannot jeopardize the continued existence of a species listed as threatened or endangered or result in the destruction or adverse modification of designated critical habitat by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS) (Chapter 1, Introduction, Section 1.3.2, Endangered Species Act).

Listed species in the analysis area for the operations and maintenance of the WVS include bull trout (listed as threatened in 1998), Upper Willamette River (UWR) spring Chinook salmon (listed as threatened in 1999), and UWR winter steelhead (also listed as threatened in 1999). Pacific lamprey are an ESA species of concern. Northwestern pond turtles were candidates for listing as a Federally threatened species under the ESA as of April 2025.

Southern Resident killer whales are ESA listed as endangered, but they do not inhabit the EIS alternatives analysis area[2]. There would be increases in adult UWR Chinook salmon abundance under all action alternatives, which would benefit Southern Resident killer whales. There is some uncertainty on the range of this benefit since UWR Chinook salmon comprise only a small percentage of Southern Resident killer whale prey. The hatchery mitigation program would continue to provide salmon available as prey to Southern Residents under the No-action and action alternatives.

Dams along the Willamette River and its tributaries block access to substantial portions of spawning and rearing habitat for listed fish species and degrade remaining downstream riverine habitats (NMFS 2008; USFWS 2008). Fish passage, both the passage of adults migrating upstream to spawn and juveniles (smolts) migrating downstream toward the ocean, is believed to be a limiting factor for recovery of ESA-listed and other native migratory fish (NMFS 2008). Altered water temperatures and flows also contribute to adverse impacts on bull trout, UWR

[2] Although Southern Resident killer whales are not in the EIS alternatives analysis area, this species was addressed in the 2023 Biological Assessment.

spring Chinook salmon, and UWR winter steelhead and their habitats (NMFS 2008; USFWS 2008).

5 - Preferred Alternative

The DEIS identified Alternative 5 as the Preferred Alternative; it is also the Preferred Alternative analyzed in the FEIS. USACE developed Alternative 5 to (1) improve fish passage throughout the WVS, (2) to manage water quality downstream of WVS dams using a combination of modified operations and structural improvements, and (3) to balance water management flexibility to meet downstream water requirements for fish and wildlife.

Operations under Alternative 5 include implementing the NMFS 2024 Biological Opinion Reasonable and Prudent Alternative, including Interim Operations for downstream fish passage and temperature management. As required under the NMFS 2024 Biological Opinion, USACE would implement the NMFS 2008 Biological Opinion minimum flow targets until USACE and NMFS develop revised flow targets.

Under Alternative 5, USACE would construct fish passage structures at Detroit, Foster, and Lookout Point Dams, and use operations to aid fish passage at Green Peter and Cougar Dams. Measures under Alternative 5 would include:

- Construction of a selective withdrawal structure for temperature management at Detroit Dam.
- Construction of a small temperature management structure in the adult fish ladder at Foster dam.
- Operations to manage downstream temperatures at Green Peter Dam.
- A fall drawdown to support fish passage at Fall Creek Reservoir.
- Operations of fish facilities and adult fish transport above the dams.
- Operations for environmental flows under the Sustainable Rivers Program.
- Gravel augmentation downstream of Cougar, Blue River, Foster, and Big Cliff Dams.
- Nature-based approach to maintaining revetments.

6 - Areas of Controversy and Issues Raised by Agencies and the Public

Areas of controversy are addressed as issues important to agencies and the public. USACE identified these issues from the public scoping process, public comments on the DEIS, and comments from Cooperating Agencies (Table ES-2).

Table ES-2. Summary of Key Concerns Identified During Environmental Impact Development Process[1].

Issue Category	Summary of Concern
NEPA Process/Scope of Review, Public Involvement, Endangered Species Act Compliance	EIS scope of review was too narrow; information on the EIS review process. Sufficiency of the Proposed Action definition as too narrow or too broad. Range of alternatives should include dam removal. Public outreach was either sufficient or insufficient. Requests to extend the DEIS comment period. Effects from construction activity timing and requests for site-specific information. Requests for regulating outlet improvements. Concerns highlighting specific resource impacts such as fish, recreation, water quality, etc. Prioritizing effects and a given resource. Inquires regarding implementation of the 2008 NMFS Biological Opinion. Lack of research, monitoring, and evaluation under the alternatives.
Injunction Measures/Interim Operations	Inquiries regarding Interim Operations timing and their relationship to alternative implementation. Requests for commitments to continue with Interim Operations based on performance standards equal to, or exceeded by, new measures.
Flood Risk Management	Suggestions to improve flood protection systems while also balancing flood mitigation with fish and wildlife needs.

Issue Category	Summary of Concern
Hydropower Operations	Requests for hydropower deauthorization/modifying or reducing hydropower operations to prioritize fish passage and ecosystem health. Requests to ensure hydropower availability during black outs/islanding. Inquiries regarding alternative energy sources.
Revetements	Suggestions for revetment modifications, removal, management. Concerns regarding impacts on river ecosystems, habitat connectivity, increased erosion, aquatic and vegetative habitat loss.
Adaptive Management Plan	Inquiries regarding governance/regulatory agency engagement, timing, transparency, collaboration. Suggestions to incorporate climate change-related effects. Requests for further explanations of adaptive management. Requests for additional monitoring information.
Climate Change	Inquiries and concerns regarding water supply planning related to reduced snowpack, higher and more frequent peak flows, and lower summer stream flows due to changing conditions. Request to incorporate recent data into analyses. Requests to model future impacts on water resources specific to the analysis area. Concerns regarding drought and related fish mortality from operations. Concerns regarding increased cumulative effects from wildfires on water quality, stored water for recreation opportunities, recreational fish management.
Cumulative Effects of Ongoing Actions within the Willamette River Basin	Concerns regarding effects of multiple, ongoing actions in the Willamette River Basin on water quality, fish population, habitat connectivity, cultural resources, etc.

Issue Category	Summary of Concern
Effects on Fish and Wildlife	Inquiries regarding fish population protections. Requests for improved fish and aquatic habitat. Incorporating the value of marine-derived nutrients into the analyses of fish effects. Address effects on native species restoration and conservation. Inquiries regarding hatchery production and programs. Address collection facility survival. Address recreational fishing impacts. Inquiries and suggestions for Impact assessments, data, and modeling used for analyses. Additional information on model limitations. Additional information on life cycle modeling. Requests to balance water management to highlight fish concerns. Additional information on the timing of effects on fish.
Effects on ESA-listed Species – **UWR Chinook salmon, UWR steelhead, bull trout, lamprey, and Southern Resident killer whales**	Concerns regarding interruptions to fish migration from passage barriers. Inquiries regarding population effects and genetic interactions. Inquiries regarding collection and transport effects and harvest/survival rates and risks. Inquiries regarding limiting factors, including prey quantity and quality. Requests to avoid jeopardy under the ESA and to address species recovery. Inquiries regarding bull trout reintroduction. Requests to clarify performance metrics. Concerns regarding habitat impacts such as connectivity and water quality conditions (e.g., flow, pollution, temperature, sediment).

Issue Category	Summary of Concern
Water Quality	Requests to ensure Clean Water Act compliance. Address impacts on temperature, total dissolved gas, turbidity, mercury, and harmful algal bloom parameters, including incorporation of best available information. Inquiries regarding the costs of water treatment from increased sediment. Concerns regarding availability and quality of drinking water.
Socioeconomics	Concerns regarding impacts on local economies related to agriculture, water supply, recreation, and tourism. Address economic effects on recreation fishing.
Water Supply	Inquiries regarding water storage capacity and allocation, refill timing, and related seasonal operations. Address irrigation and municipal water use and future demands. Concerns regarding the effects from changing water storage on fish and aquatic habitat. Concerns regarding the effects on farmers, tribal communities, and local residents reliant on water for irrigation, drinking supply, and cultural practices. Concerns regarding the effects of water supply during drought years.
Recreational Opportunities	Concerns regarding the effects of operations on recreation opportunities and community revenue and identity. Concerns regarding the effects on boat ramp use. Concerns regarding the effects of operations on resident and gamefish for recreational fishing. Concerns regarding the effects on in-river recreation use and safety. Concerns regarding the effects of dispersed camping in undeveloped areas from visitor displacement if water-based recreation opportunities are not available. Concerns over potential increases in wildfires from dispersed camping. Address impacts on managing agencies.

Issue Category	Summary of Concern
Cultural Resources	Tribal concerns regarding degradation and mitigation. Tribal concerns regarding access for tribal members to conduct cultural practices in the analysis area. Concerns regarding the protection of lamprey and fish species as cultural resources.
Tribal Interests	Concerns regarding the cultural significance of fish and water resources to tribal communities.

[1] Appendix P, Public Scoping Report summarizes public scoping comments.

7 - Issues to be Resolved

The Proposed Action attempts to balance the need to continue operating and maintaining the WVS under Congressional authorization without jeopardizing the continued existence of listed fish species. Related to this issue is operation and maintenance of the system while complying with the NMFS 2024 Biological Opinion (NMFS 2024).

USACE develop seven alternatives that incorporate a range of operational and structural measures to aid fish passage. Implementation of each alternative was analyzed across several resources of the human environment to demonstrate adverse and beneficial effects, including effects on fish and aquatic habitat. The agency decision maker will use these analyses to select an alternative to implement over the next 30 years. This decision will balance anticipated effects to the human environment with the need to operate and maintain WVS for Congressionally authorized purposes without jeopardizing the continued existence of listed species.

8 - Major Conclusions

8.1 Hydrologic Processes

In comparison to the No-action Alternative (NAA), operations under Alternative 1 and Alternative 4 would store more water in the spring and release it during the summer and fall; however, operations would differ between Alternative 1 and Alternative 4. Operations under Alternative 2A and Alternative 2B would store more water during spring for release in the summer and fall as compared to the NAA, but less than operations under Alternative 1 or Alternative 4 while incorporating selected drawdowns.

Operations under Alternative 3A and Alternative 3B would include spring reservoir drawdowns at different, selected reservoirs and deeper fall drawdowns at WVS reservoirs in the Santiam River, McKenzie River, and Middle Fork Willamette River Subbasins—excluding Foster Dam and the re-regulating dams. Operations under Alternative 5 would be the same as Alternative 2B, but USACE would prioritize higher spring flow during dry years under Alternative 5 as compared to Alternative 2B.

The degree of effect under the NAA would be none/negligible. Comparatively, the degree of effect under all action alternatives would be major.

8.2 Geology and Soils

Effects on geologic resources would range from none/negligible to moderate under all alternatives except the NAA and Alternative 1. Moderate effects on permanent materials removal would occur at Blue River, Cougar, Hills Creek, Lookout Point, Detroit, and Green Peter Reservoirs.

8.3 Water Quality

Direct, adverse effects on water quality in the analysis area would continue to varying degrees under all alternatives with some improvements depending on the alternative.

8.3.1 Water Temperature

Although moderate, adverse water temperatures would continue under the NAA, they would improve in varying locations below dams under the action alternatives, except Alternative 3A. Further, temperature impacts would be localized to stream reaches immediately below dams.

Operations under Alternative 2B and Alternative 5 would improve the most from adverse water temperature conditions system-wide over the 30-year implementation timeframe.

8.3.2 Total Dissolved Gas

Direct effects on water quality from total dissolved gas (TDG) would range from slightly to moderately adverse under the NAA. Increases in adverse conditions would occur in some locations below dams under all alternatives except Alternative 1 and Alternative 4 where the most improvements would occur.

8.3.3 Turbidity

Ongoing direct, adverse effects of turbidity in downstream reaches would occur under all alternatives. However, benefits from sediment trapped at all reservoirs during high-flow events would occur under all alternatives.

8.3.4 Harmful Algal Blooms and Mercury

Slight, adverse, direct effects from harmful algal blooms and mercury would occur under the NAA with increases in these adverse conditions under all action alternatives. Adverse effects would be greatest under Alternative 3A and Alternative 3B.

8.4 Vegetation and Wetlands

Major, adverse effects to vegetation and wetlands from limited floodplain connectivity would occur under all alternatives. Major beneficial effects from gravel bars that would improve connectivity and from revetment improvements that may improve native riparian seed banks would occur under all action alternatives.

Major, adverse effects would also occur to vegetation and wetlands from frequent reservoir elevation changes that increase the potential for invasive establishment under all alternatives.

Moderate, adverse effects would occur to vegetation during spring refill by inhibiting new plant establishment under all action alternatives, depending on the reservoir. Moderate, adverse effects would also occur to special-status plant species and wapato from refill potential to inhibit establishment under all action alternatives.

8.5 Fish and Aquatic Habitat

8.5.1 Upper Willamette River Chinook Salmon

8.5.1.1 Hatchery Mitigation

Under the NAA, there would be adverse effects to UWR Chinook salmon in all subbasins from domestication and gene mixing, increased competition, disease transfer, increased exploitation of native fish, and effects from downstream water quality from hatchery wastewater. However, beneficial effects would occur to sport fishing and harvest opportunities, prey sources for other fish, and increased Chinook salmon spawner abundance.

Effects under all action alternatives would be the same as those under the NAA, but with reduced number of hatchery UWR Chinook salmon released upstream, reduced proportion of hatchery-origin spawners, and increased risks to bull trout from the rainbow trout hatchery program and sport fishing.

8.5.1.2 Reservoir/Lake-like Habitat

Under the NAA, moderate to substantial, adverse effects would occur to UWR Chinook salmon juveniles from reservoir operations due to delayed migration, increased predation, and disease in all subbasins. However, beneficial effects would occur to juveniles from high growth rates. Exceptions to adverse and beneficial effects would occur at Green Peter and Blue River Reservoirs where there are no Chinook salmon present. There would be minor, adverse effects at Fall Creek Reservoir due to annual drawdowns to streambed.

Effects under the action alternatives would be the same as those summarized under the NAA. Beneficial effects would occur from improvements in passage that would reduce the duration that juveniles are in reservoirs. The degree of benefit would vary depending on alternative and reservoir. Increased adverse effects to UWR Chinook salmon habitat within Detroit and Lookout Point Reservoirs would occur under Alternative 3B as compared to the NAA.

8.5.1.3 Riverine Habitat

Substantial, adverse effects to riverine habitat would occur in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Adverse effects from TDG would continue to occur below dams under all alternatives.

Beneficial effects to riverine habitat from would occur under the NAA from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons.

Effects on riverine habitat under most action alternatives would be similar to effects under the NAA but would have varying degrees of improvement compared to the NAA depending on alternative and reservoir. Additionally, beneficial effects on riverine habitat would occur in the Long Tom River Subbasin under Alternative 1 and Alternative 4 from increased rearing due to improved habitat access with removal of drop structures.

However, under Alternatives 2A, 2B, 3B, and 5, there would be an increase in adverse effects on water quality in riverine habitat due to Green Peter Reservoir drawdowns. Increased adverse effects on riverine habitat would occur in all subbasins under Alternative 3A and Alternative 3B compared to the NAA.

8.5.1.4 Dam Passage Conditions

Under the NAA, slight to moderate, adverse effects would occur in all subbasins from collection of UWR Chinook salmon adults and transport above dams. Substantial, adverse effects due to poor downstream passage conditions would occur at Detroit and Big Cliff Dams; moderate, adverse effects would occur at Foster Dam.

The same or slight to moderate, adverse effects would occur under the action alternatives in comparison to the NAA, depending on alternative and reservoir. There would be a slight trend toward beneficial effects from downstream passage due to regulating outlet improvements in the McKenzie River Subbasin under Alternative 5 during Interim Operations. Under Alternative 3A, passage conditions for UWR Chinook salmon would be similar to the NAA at Cougar Dam, but adverse effects would trend toward beneficial effects.

8.5.1.5 Population Performance

UWR Chinook salmon population performance would be substantially adverse under the NAA except for performance in the South Santiam River Subbasin, which would be moderately to substantially adverse. Slight to substantial, adverse effects would occur under the action alternatives depending on alternative and reservoir.

Substantial, adverse effects on population performance would occur under Alternative 1 in the McKenzie River Subbasin. Moderate, adverse effects would occur in all subbasins under Alternative 3A and Alternative 3B with moderate to substantial effects anticipated in the Middle Fork Willamette River under both alternatives.

8.5.2 Upper Willamette River Steelhead

8.5.2.1 Hatchery Mitigation

Under the NAA, there would be adverse effects to UWR steelhead in the North and South Santiam River Subbasins from domestication and gene mixing, increased competition, disease transfer, increased exploitation of native fish, and effects from downstream water quality from hatchery wastewater.

However, beneficial effects would occur to sport fishing and harvest opportunities, prey sources for other fish, and increased steelhead spawner abundance.

Effects under all action alternatives would be the same as those under the NAA, but with adverse effects trending toward beneficial due to increased abundance of UWR steelhead in the North and South Santiam River Subbasins.

8.5.2.2 Reservoir/Lake-like Habitat

Under the NAA, moderate to substantial, adverse effects would occur to UWR steelhead juveniles from reservoir operations in the North and South Santiam River Subbasins. These effects would be due to delayed migration, increased predation, and disease. However, beneficial effects would occur on juveniles from high growth rates. Exceptions would occur at Green Peter and Blue River Reservoirs where there are no UWR steelhead present.

Effects under the action alternatives would be the same as under the NAA, but with reduced adverse effects in some reservoirs depending on alternative and reservoir. There would be an increase in adverse effects on UWR steelhead under Alternative 3B and Alternative 5 within Detroit Reservoir in comparison to the NAA.

8.5.2.3 Riverine Habitat

Substantial, adverse effects would occur under the NAA in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Adverse effects from TDG would continue to occur below dams under all alternatives.

Beneficial effects from would occur under the NAA from dam and reservoir operations that augment flows and manage water temperature during low flow seasons.

Effects on riverine habitat under most action alternatives would be similar to effects summarized under the NAA, but there would be slight to moderate benefits from habitat improvements compared to the NAA depending on alternative and reservoir.

However, under Alternatives 2A, 2B, 3B, and 5, there would be an increase in adverse effects on water quality in riverine habitat due to the Green Peter Reservoir drawdowns. Increased adverse effects on riverine habitat would occur in the North Santiam and South Santiam River

Subbasins under Alternative 3A and Alternative 3B and in the North Santiam River Subbasin under Alternative 5 as compared to the NAA.

8.5.2.4 Dam Passage Conditions

Under the NAA, slight, adverse effects to UWR steelhead would occur from collection of adults and transport upstream above dams in the North and South Santiam River Subbasins. Substantial, adverse effects due to poor downstream passage conditions would occur at Detroit, Big Cliff, and Foster Dams.

The same or slight to moderate, adverse effects would occur under the action alternatives in comparison to the NAA, depending on alternative and reservoir.

8.5.2.5 Population Performance

UWR steelhead population performance[3] would be substantially adverse in the North Santiam River Subbasin under the NAA and moderately to substantially adverse in the South Santiam River Subbasin. Slight to moderate, adverse effects would occur under the action alternatives depending on alternative and reservoir. Moderate, adverse effects would occur in both subbasins under Alternative 3A and Alternative 3B.

8.5.3 Bull Trout

8.5.3.1 Hatchery Mitigation

Under the NAA, adverse effects to bull trout would occur in all subbasins from sport fishing, habitat competition, and effects on downstream water quality from hatchery wastewater. Beneficial effects would occur from increased forage where hatchery trout releases overlap with bull trout distributions.

Effects under the action alternatives would be the same as those under the NAA, but with increased risks to bull trout from the rainbow trout hatchery program and sport fishing below dams. These effects would occur because of improved passage conditions at dams in the North Santiam River under Alternatives 1, 2A, 3A, 4, and 5 and in the McKenzie River Subbasin under Alternatives 2A, 2B, and 4. These adverse effects would also occur in the Middle Fork Willamette River Subbasin under Alternative 4.

8.5.3.2 Reservoir/Lake-like Habitat

Substantial, beneficial effects would occur for bull trout under most alternatives in the North Santiam, McKenzie, and Middle Fork Willamette River Subbasins under the NAA due to feeding

[3] Fish population performance, or stock assessment, measures the health and abundance of a fish population, helping managers make decisions about fisheries and conservation by evaluating factors like fishing intensity, mortality, growth, and recruitment.

and growth opportunities in reservoirs. However, substantial, adverse effects would occur in the McKenzie River Subbasin under Alternative 2B and Alternative 3B due to drawdowns.

Moderate to substantial, adverse effects on habitat availability would occur in the North Santiam River Subbasin under Alternative 3A and Alternative 5, with moderate, adverse effects in the North Santiam River subbasin under Alternative 3B due to drawdowns.

8.5.3.3 Riverine Habitat

Substantial, adverse effects would occur to bull trout under the NAA in all subbasins in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations. Adverse effects from TDG would continue to occur below dams under all alternatives.

Beneficial effects would occur under the NAA in all subbasins from dam and reservoir operations that augment flows and manage water temperature management during low flow seasons. Additionally, beneficial effects on riverine habitat would occur in the Long Tom River Subbasin under Alternative 1 and Alternative 4 from increased rearing due to improved habitat access with removal of drop structures.

Effects to bull trout under most action alternatives would be similar to those under the NAA, but with slight differences in benefits depending on alternative and subbasin. Slight to moderate benefits under Alternative 1 would occur during low flow seasons from flow augmentation to meet minimum flow targets, moderate increased benefits from temperature management, and reduced TDG.

There would be an increase in adverse riverine habitat for bull trout in the South Santiam River Subbasin under Alternatives 2A, 2B, 3A, 3B, and 5. Increased adverse effects would also occur in the McKenzie River and Middle Fork Willamette River Subbasins under Alternative 3A and Alternative 3B.

8.5.3.4 Dam Passage Conditions

Under the NAA, slight, adverse effects to bull trout would occur in all subbasins from collection and upstream transport of adults above dams in all subbasins. Moderate to substantial, adverse effects from upstream passage would occur at Hills Creek Dam. Substantial, adverse effects due to poor downstream passage conditions would occur at Detroit, Big Cliff, and Hills Creek Dams.

The same or slight to moderate, adverse effects would occur to bull trout under the action alternatives in comparison to the NAA, depending on alternative and reservoir.

8.5.4 Pacific Lamprey

8.5.4.1 Hatchery Mitigation

Slight, adverse effects to Pacific lamprey would occur in all subbasins and under all alternatives from predation and effects on downstream water quality from wastewater.

8.5.4.2 Reservoir/Lake-like Habitat

Moderate, adverse effects would occur to Pacific lamprey in the Middle Fork Willamette River Subbasin under all alternatives from drawdowns at Fall Creek Reservoir. Pacific lamprey are not present above WVS dams, except for Fall Creek Dam.

8.5.4.3 Riverine Habitat

Substantial, adverse effects would occur to Pacific lamprey under the NAA in winter and spring from reduced peak flows and materials transport due to dam and reservoir operations in all subbasins. Adverse effects from TDG below dams would occur under all alternatives in all subbasins.

Beneficial effects would occur under the NAA from flow augmentation and water temperature management due to dam and reservoir operations during low flow seasons.

Effects to Pacific lamprey under the action alternatives would vary as compared to those under the NAA depending on alternative and reservoir. Increased and slight to moderate benefits would occur in the North Santiam River Subbasin under Alternative 1. However, increased adverse effects would occur in this subbasin under Alternatives 3A, 3B, and 5 from drawdown water quality effects and downstream habitat availability.

Increased adverse effects to Pacific lamprey would also occur in the South Santiam River Subbasin under Alternatives 2A, 2B, 3A, 3B, and 5 from water quality and habitat availability effects.

Increased adverse effects would occur in the McKenzie River Subbasin under Alternatives 2B, 3A, 3B, and 4. Slight to moderate beneficial effects would occur under Alternative 1, 2A, and 4 in this subbasin.

Increased adverse effects to Pacific lamprey would also occur in the Middle Fork Willamette River Subbasin under Alternatives 3A, 3B, and 5 from water quality and reduced habitat availability effects. Slight to moderate beneficial effects would occur under Alternative 1, 2A, 2B, and 4 in this subbasin.

Riverine habitat effects in the Coast Fork River and Long Tom River Subbasins would be the same as those under the NAA. Additionally, beneficial effects on riverine habitat from the removal of drop structures, resulting in improved habitat access and increased rearing, would occur in the Long Tom River Subbasin under Alternative 1 and Alternative 4.

8.5.4.4 Dam Passage Conditions

Moderate, adverse effects to Pacific lamprey would occur in the Middle Fork Willamette River Subbasin due to Fall Creek Reservoir drawdowns under all alternatives. Adverse effects from passage effects at drop structures would also occur in the Long Tom River Subbasin under all alternatives except Alternative 1. Beneficial effects would occur in this subbasin under Alternative 1 and Alternative 4 from increased access to spawn and rear upstream with drop structure removal.

8.5.5 Resident Fish and Gamefish

8.5.5.1 Hatchery Mitigation

Adverse effects to resident fish and gamefish would occur under the NAA in all subbasins from sport fishing, habitat competition, and effects on downstream water quality from wastewater. Beneficial effects would occur from increased forage for some species and life stages.

Effects under the action alternatives would be the same as those under the NAA, but with increased risks from the rainbow trout hatchery program and sport fishing below dams. These effects would occur because of increased movement of resident fish below dams with improved passage conditions. Within the Willamette River Basin, these risks would be greatest under Alternatives 2A, 2B, 3B, and 4 because of the number of subbasins affected.

8.5.5.2 Reservoir/Lake-like Habitat

Substantial, beneficial effects to resident fish from feeding and growth opportunities in reservoirs would occur in all subbasins under the NAA and Alternative 1 and Alternative 4. These benefits would occur under all alternatives, but with the following exceptions:

- Moderate, adverse effects in the South Santiam River Subbasin under Alternatives 2A, 2B, and 3A.
- Substantial, adverse effects in the McKenzie River Subbasin under Alternative 2B and Alternative 3B.
- Substantial, adverse effects in the South Santiam River Subbasin under Alternative 3B.
- Substantial and moderate, adverse effects in the Middle Fork Willamette River Subbasin under Alternatives 3A, 3B, and 5.

Oregon Department of Fish and Wildlife stocks of rainbow trout and kokanee would moderate adverse effects to sport fishing opportunities under the NAA in all subbasins However, deep drawdowns would reduce these benefits under all action alternatives, except Alternative 1 and Alternative 4, depending on reservoir operations under each alternative.

8.5.5.3 Riverine Habitat

Effects to resident fish and gamefish would be the same as those for bull trout.

8.5.5.4 Dam Passage Conditions

Passage conditions for resident fish and gamefish would range from slightly adverse to substantially adverse across all subbasins and alternatives. Conditions would be substantially adverse in the Coast Fork River and Long Tom River Subbasins under all alternatives. Alternatives 1, 2A, and 4 would have the lowest degree of adverse effects in all subbasins.

8.6 Wildlife and Habitat

Moderate, beneficial effects due to sustained water sources from summer reservoir elevations that support aquatic prey species would occur to wildlife species under all alternatives. However, moderate, adverse effects would occur from drawdowns increasing the distance from sheltering/foraging habitats to the water's edge, requiring some species to travel longer distances for water under Alternatives 2A, 2B, 3A, 3B, and 5.

Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations would occur under all alternatives. This would force turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and would also increase competition for resources.

Major, adverse effects on wildlife habitat from floodplain disconnection would occur under all alternatives. Minor, beneficial effects from gravel augmentation and revetment improvements that would provide downstream habitat would occur under the action alternatives.

8.7 Air Quality and Greenhouse Gas Emissions

WVS operations and maintenance would result in greenhouse gas emissions under all alternatives. Climate change-related effects would result in moderate to substantial, adverse greenhouse gas emissions under all alternatives from dam operations system-wide. These effects would combine with effects from other sources on a large, geographic scale and would likely be long-term and recurring over the 30-year implementation.

8.8 Socioeconomics

Socioeconomic effects, such as recreation-related revenue and employment earnings, would occur at the local, reservoir level. These effects would be substantially beneficial under the NAA and Alternative 1 and Alternative 2A. Similar benefits would occur under Alternative 4 and

Alternative 5, but with negligible decreases in benefits to the Albany and Salem Metropolitan Statistical Areas[4] communities.

Substantial, adverse effects would occur in recreation-related revenue and employment to the Eugene Metropolitan Statistical Area and to the communities near Detroit, Cougar, and Lookout Point Reservoirs during the peak recreation season under Alternative 3A. Similarly, substantial, adverse effects would occur to the Eugene Metropolitan Statistical Area and communities localized to Detroit, Blue River, and Lookout Point Reservoirs in late summer under Alternative 3B.

8.9 Regional Power System Generation and Transmission

8.9.1 Regional Power System Reliability

Long-term, slight, beneficial power system reliability would occur under all alternatives with slight, additional power provided under Alternative 1 and Alternative 4. Although beneficial, the WVS would generate less regional power under Alternatives 2A, 2B, 3A, 5, and Interim Operations.

8.9.2 Willamette Valley System Dam Generation

The WVS power generation impacts would be long term and substantially beneficial under the NAA and Alternative 4. Alternative 1 would be more beneficial than the NAA because of slightly more generated power. Although beneficial, the WVS dams would generate less power under Alternatives 2A, 2B, and 5.

There would be a 50 percent power generation decrease from WVS dams under Alternative 3A and Alternative 3B as compared to the NAA, but generation would remain beneficial. Although beneficial, the WVS dams would generate moderately less power under the Interim Operations.

8.9.3 Transmission System Reliability

Long-term, slight, adverse effects to transmission reliability would occur under the NAA and Alternative 1 and Alternative 4. Long-term, moderate, adverse effects would occur under all other action alternatives. Medium term, moderate, adverse effects in transmission reliability would occur under the Interim Operations.

Hills Creek and Cougar Dams would continue to operate islanded (isolated) as needed under the NAA and Alternatives 1, 2A, and 4. However, islanded operations may be compromised during power outages at Cougar Dam under Alternatives 2B, 3A, 3B, 5, and the Interim Operations. Additionally, Hills Creek Dam would not provide islanding under Alternative 3A and

[4]The analysis area to assess existing socioeconomic conditions and potential effects in Section 3.11, Socioeconomics, is the Salem, Albany, and Eugene, Oregon Metropolitan Statistical Areas (MSAs). MSAs are defined in the USACE Regional Economic System (RECONS) model as Core-based Statistical Areas (CBSAs). CBSAs are based on population and labor force commuting patterns.

Alternative 3B. This would result in substantial, adverse effects to the communities of Blue River (Cougar Dam) and Oakridge (Blue River Dam) during power outages.

8.10 Economic Viability

Long-term, slight, beneficial economic viability of power generation would continue under the NAA. In contrast, long-term, substantial, adverse viability would occur under all action alternatives. Medium-term, substantial, adverse effects would occur under the Interim Operations.

8.11 Water Supply

Substantially, beneficial water supply would occur system-wide from stored water under the NAA and Alternatives 1, 2A, and 4 because conservation storage would result in enough stored water to meet the municipal and industrial, and agricultural irrigation demands in almost all years. Moderately beneficial supply would occur under Alternative 2B and Alternative 5. Slightly beneficial water supply from stored water would occur under the Interim Operations. However, exceptions would occur under all alternatives during dry years or when USACE needs to reduce water supply to meet flow targets.

Substantially, adverse effects on water supply from stored water would occur under Alternative 3A and Alternative 3B.

Water supply from river flow would be beneficial under all alternatives except during dry years. However, adverse effects on river flow supply would occur under Alternative 3A from the North Santiam River and under Alternative 3B from the South Santiam River.

8.12 Recreation Opportunities

8.12.1 Water-based Opportunities

Substantial, beneficial effects to water-based recreation opportunities during the peak recreation season would occur under the NAA and the action alternatives with some exceptions.

- Substantial, adverse effects would occur at Cougar Reservoir as the deep fall and spring reservoir drawdowns make the reservoir inaccessible for water-based recreation under Alternatives 2B, 3A, and 5.
- Substantial, adverse effects would occur at Lookout Point and Detroit Reservoirs during the peak recreation season under Alternative 3A.

- Substantial, adverse effects would occur at Lookout Point, Detroit and Blue River Reservoirs during the latter portion of the recreation season in late summer under Alternative 3B.
- Substantial, adverse effects would also occur at Hills Creek, Blue River, and Green Peter Reservoirs during the late summer under Alternative 3A.

8.12.2 Recreation Site Management

Adverse effects to land management agencies and organization financial and staffing resources, from displaced recreation management would occur as a result of adverse effects to water-based recreation under all alternatives. However, under the NAA, moderate to substantial effects would occur only during the latter portion of the recreation season at some reservoirs depending on the amount of precipitation and timing of the drawdowns.

8.13 Hazardous, Toxic, and Radioactive Substances

Moderate, adverse effects would occur throughout the WVS under all alternatives from legacy contamination. These would be long-term effects.

8.14 Drinking Water

Effects to water supply are summarized in Section 8.9, Water Supply. Adverse effects to drinking water quality would occur from turbidity in all reservoirs under all alternatives. These effects would be substantially more adverse under Alternatives 2A, 2B, 3A, 3B, and 5 depending on the reservoir:

- Below Foster Reservoir under each of these alternatives.
- Below Cougar Reservoir under Alternatives 2B, 3B, and 5.
- Below Dexter and Big Cliff Reservoirs under Alternative 3A and Alternative 3B.
- Below Hills Creek Reservoir under Alternative 3B.

8.15 Cultural Resources

Moderate to major, adverse effects would occur to cultural resources throughout the WVS depending on alternative and reservoir. Effects would occur from annual drawdowns and refills that would erode the physical integrity of archaeological sites and expose sites to unauthorized artifact collection by the public. Additionally, adverse effects would occur under the action alternatives from modifications of structures or new structures in historic districts.

8.16 Visual Resources

Effects on visual resources would range from negligible under all alternatives from routine maintenance to major effects under Alternatives 2B, 3A, and 3B. Under these action alternatives, reservoirs would not be refilled during high visitor-use summer months or deep

drawdowns would occur during typically scenic, early fall months. Major visual contrast effects would occur in viewsheds associated with Cougar, Detroit, Lookout Point, Hills Creek, Green Peter, and Blue River Reservoirs under these alternatives.

Major effects to visual resources under Alternative 2B would occur only at Cougar Reservoir but would be combined with structural elements at Cougar Dam.

8.17 Tribal Resources

Potential direct, indirect, and climate change effects of the alternatives on tribal resources encompass all resource effects analyzed in the EIS. As such, the degrees of effects are broad, ranging from substantial under some resources and alternatives as summarized above, to minor or no effect under others. These effects are in Section 3.25, Summary of Direct and Indirect Environmental Consequences.

8.18 Summary of Unavoidable Adverse Effects

See Table ES-3, below.

Table ES-3. Summary of Unavoidable Adverse Effects under the Preferred Alternative as Compared to the No-action Alternative (table continued below).

Alternative	Hydrologic Processes	Geology and Soils	Water Quality	Vegetation and Wetlands	Fish and Aquatic Habitat	Wildlife and Habitat	Air Quality and Greenhouse Gases	Socioeconomics
No-action	Detroit and Green Peter Reservoir operations would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years in late fall. Operations at Foster Reservoir would vary from rule curve during flood operations. Flow would vary within Biological Opinion targets, falling to about 700 cfs in fall of very dry years in the North Santiam River at Mehama.	No unavoidable, adverse effects from landslide risk or debris removal.	Slight to moderate, adverse temperature effects across monitored subbasins. Slight to moderate, adverse TDG effects across monitored locations. Adverse (and beneficial) effects from turbidity across monitored locations, except slightly adverse at Salem. Slightly adverse effects from harmful algal blooms at all monitored locations. Slightly adverse effects from mercury at all monitored locations.	Minor, adverse effects to vegetation from frequent water fluctuations prohibiting plant establishment and succession, which may increase the potential for the establishment of invasive-dominated plant communities. Major, adverse effects to vegetation and wetlands from limited floodplain connectivity. Major, adverse effects to vegetation in reservoirs from frequent reservoir elevation changes.	Major, adverse effects from upstream and downstream fish passage. Adverse effects on downstream flow and water quality (see Water Quality, above). Degree of adversity would vary by season and subbasin. Major, adverse effects from decreased materials transport in combination with land use practices, degrading downstream habitat. Moderate to major, adverse effects from bank protection structures and flow operations, preventing downstream habitat connectivity and peak flows. Major, adverse effects within reservoirs on competition, predation, and delayed migration. Adverse effects from hatcheries resulting in domestication and genetic introgression, increased competition, disease transfer, increased exploitation of native fish, effects on downstream water quality from effluent.	Major, adverse due to flood operations/revetments causing floodplain disconnection, habitat fragmentation, and migration limitations. Moderate, adverse effects to northwestern pond turtles from low winter reservoir elevations forcing turtles to travel farther from the aquatic environment to terrestrial overwintering habitat and increasing competition for resources.	Minor, adverse effects on air quality localized to dams in the medium term from operations. Minor, adverse effects on air quality at a large scale from climate change-related operational effects. Moderate to substantial adverse effects from greenhouse gas emissions related to climate change effects in the long term.	No unavoidable, adverse effects from socioeconomic conditions.

Alternative	Hydrologic Processes	Geology and Soils	Water Quality	Vegetation and Wetlands	Fish and Aquatic Habitat	Wildlife and Habitat	Air Quality and Greenhouse Gases	Socioeconomics
Alternative 5	Detroit Reservoir operations would reach the top of conservation storage about 75% of years during the spring and would very rarely reach the bottom of conservation storage in the fall. Green Peter Reservoir operations would reach the top of conservation storage less than 75% of years during the spring and the bottom of conservation storage about 5% of years prior to the deeper fall reservoir drawdown. Foster Reservoir Operations same as No-action Alternative. Lower varied spring flow across all years in the North Santiam River at Mehama. About 1,000 cfs in fall of very dry years. Lower spring flow in dry years in the Santiam River at Jefferson.	Moderate, adverse effect of landslide activation risk and debris removal at Cougar Reservoir. Moderate, adverse effect from debris removal at Lookout Point, Detroit, and Green Peter Reservoirs.	Moderate, adverse temperature effects below Hills Creek and Dexter Reservoirs; slightly adverse at Salem. Same as No-action Alternative below Hills Creek and Dexter Reservoirs; substantially more adverse below Foster Reservoir. Substantially more adverse effects from turbidity below Cougar and Foster Reservoirs; slightly more adverse at Salem. Moderately more adverse effects from harmful algal blooms at Cougar and Foster Reservoirs; slightly more adverse at all other monitored locations. Moderately more adverse effects from mercury at Cougar and Foster Reservoirs; slightly more adverse at all other monitored locations.	All unavoidable, adverse effects on vegetation same as No-action Alternative. Moderate, adverse effects to wetlands at Cougar Reservoir if reservoir is unable to refill. Moderate, adverse effects to wetlands from the potential for induced landslides at Green Peter and Cougar Reservoirs from fall and spring drawdowns. Same as No-action Alternative regarding adverse effects on wetlands from floodplain connectivity. Moderate, adverse effects to special-status species and wapato from use of power and inactive pools. Major, adverse effects to wetlands from increased potential for invasive establishment from frequent reservoir elevations changes and deep drawdowns.	Same as No-action Alternative with substantial reductions in adverse effects for fish passage at dams. Same as No-action Alternative with reduced adverse effects from water quality improvements. Same as No-action Alternative with slight reductions in adverse effects in the South Santiam River Subbasin below Green Peter Dam. Same as No-action Alternative regarding bank protection structures. Same as No-action Alternative regarding in-reservoir adverse effects. Same as Same as No-action Alternative with reduced adverse effects from hatchery Chinook salmon program from increased abundance of natural-origin fish.	Same as No-action Alternative regarding adverse effects from flood operations/revetments. Same as No-action Alternative regarding adverse effects to northwestern pond turtles. Moderate, adverse due to the additional deep drawdown at Green Peter and increased distance from sheltering/foraging habitats to the water's edge requiring some wildlife species to travel longer distances for water. Moderate, adverse from dramatic changes in reservoir elevations over the year causing wetting/drying cycles for reservoir-adjacent habitats.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.

Table ES-3. Summary of Unavoidable Adverse Effects under the Preferred Alternative as Compared to the No-action Alternative, Continued.

Alternative	Power Generation and Transmission	Water Supply	Recreation Resources	Hazardous Materials	Hazardous, Toxic, and Radioactive Waste	Drinking Water	Cultural Resources	Visual Resources	Tribal Resources
No-action	Long-term, slight, adverse effects on transmission system reliability.	Adverse in all subbasins and the Mainstem Willamette River during dry years.	Potential direct, moderate to substantial, adverse effects to water-based opportunities during the latter portion of the recreation season in summer to some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns. Potential indirect, moderate to substantial, adverse effects on management during the latter portion of the recreation season in late summer at some analysis area reservoirs depending on the amount of precipitation and timing of the drawdowns due to visitor displacement.	Minor, adverse, localized effects from use of hatchery pesticides, construction, demolition, maintenance, and oil spills.	Negligible and minor adverse effects from operations and maintenance and risk from sites on the National Priorities List. Regional extent. Minor to moderate adverse effects from waste from legacy contamination. Regional extent.	Not all water uses satisfied by river flow in all years. See also water quality effects summary above.	Major, adverse effects at all reservoirs, except Big Cliff and Dexter Reservoirs from annual draft and fill that would erode physical integrity of archaeological sites in reservoirs and expose them to unauthorized collection by the public. Major, adverse effect at Fall Creek Reservoir from deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	Moderate to major, adverse effects depending on the dam, visitor numbers, and operations. Deep drawdowns with high visitor use would be more adverse than those with low visitor use. Adverse effects would occur in the short and long terms. Recurring for drawdowns and maintenance, but not permanent for maintenance activities.	Potential adverse effects on tribal resources encompass all resource effects analyzed in the EIS. As such, the degrees of effects are broad, ranging from substantial and unavoidable under some resources and alternatives to minor or no effect under others. See all summaries of unavoidable, adverse effects.

Alternative	Power Generation and Transmission	Water Supply	Recreation Resources	Hazardous Materials	Hazardous, Toxic, and Radioactive Waste	Drinking Water	Cultural Resources	Visual Resources	Tribal Resources
Alternative 5	Moderate, adverse effects on transmission system reliability. Islanding during power outages from Hills Creek Dam would be the same as under the NAA. Deep fall and spring drawdowns at Cougar Reservoir and limited ability to manage Cougar Dam for power generation would likely compromise the ability to provide power to the community of Blue River, which would be a substantial adverse effect to the community. Medium-term, substantial, adverse economic viability.	All unavoidable, adverse effects same as No-action Alternative.	Substantial, adverse effects to water-based opportunities at Cougar Reservoir with slight to moderate, adverse effects on other analysis area reservoirs due to displaced visitor use. Indirect, adverse effects at Cougar Reservoir from management requirements. Potential indirect, adverse impacts on management at nearby reservoirs from displaced visitors and related management requirements.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative.	All unavoidable, adverse effects same as No-action Alternative. Major adverse effects at Fall Creek, Cougar, Green Peter Reservoirs from deep drawdowns that would increase erosion and exposure of archaeological sites in reservoirs.	All unavoidable adverse effects same as No-action Alternative.	All unavoidable adverse effects same as No-action Alternative.